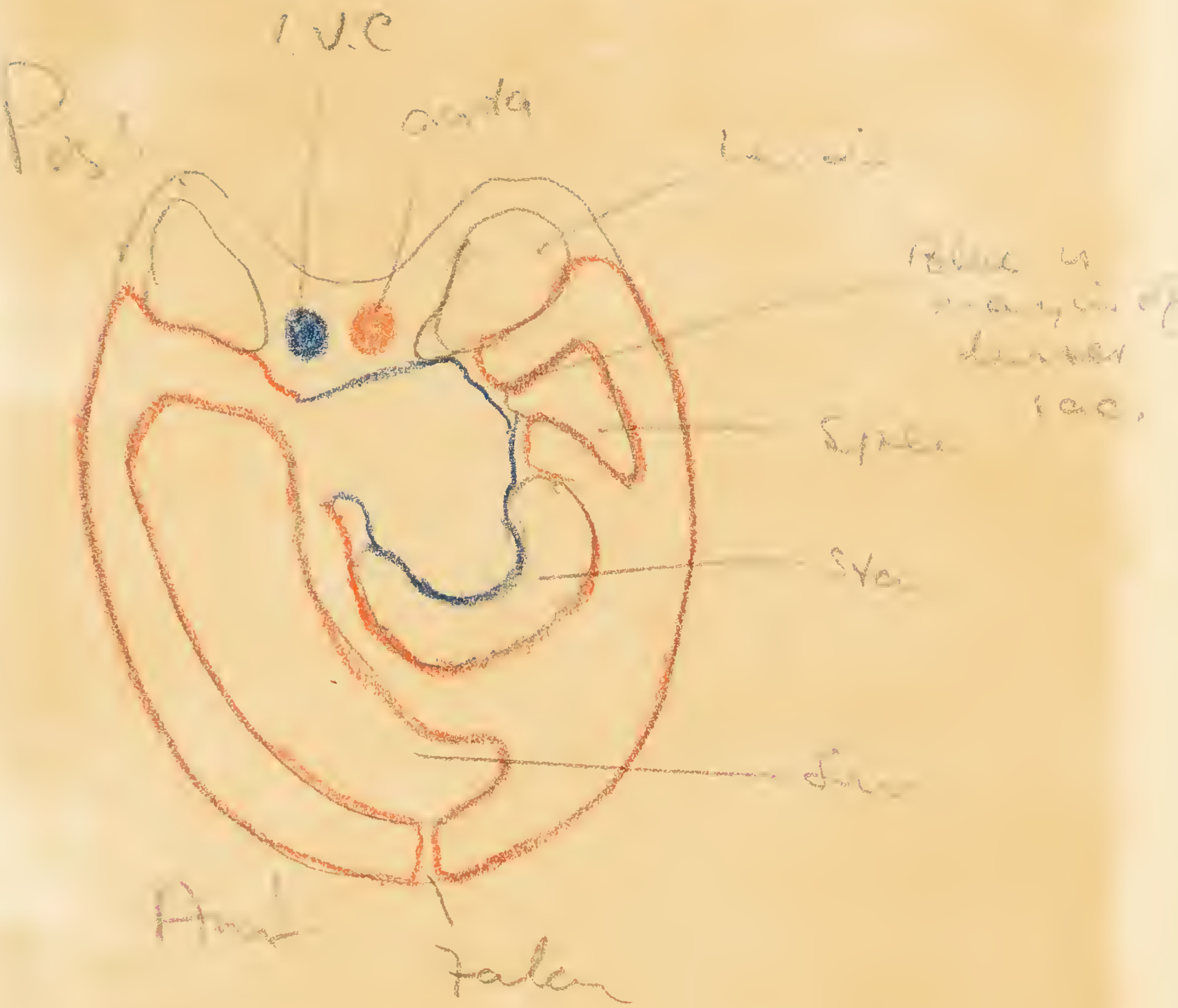

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MANUAL OF ANATOMY

DANIEL JOHN CUNNINGHAM

Demonstrator of Anatomy, University of Edinburgh, 1874–1882
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From identical Bronze Plaques in the Dissecting Rooms,
Trinity College, Dublin, and the University of Edinburgh

CUNNINGHAM'S MANUAL

OF

PRACTICAL ANATOMY

REVISED AND EDITED BY

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TENTH EDITION

VOLUME SECOND

THORAX AND ABDOMEN

WITH 24 PLATES (INCLUDING 16 RADIOGRAPHS) AND 211 OTHER ILLUSTRATIONS, MANY OF WHICH ARE COLOURED

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PREFACE TO THE TENTH EDITION

In the preparation of this edition, which appears in war-time, no great changes have been made; but the text has been revised thoroughly. The chief alterations in the text are the outcome of the continued pursuit of objects aimed at in the Ninth Edition.

In each volume, we have made some alterations in the sequence of the dissection and description where that seemed advisable; and here and there—notably in the description of the deep muscles of the Back—we have cut out descriptive detail that we thought medical students could dispense with or which can be adequately dealt with only in the large text-books.

A few of the old figures have been omitted without sacrifice of the illustration of any important structure; and a new figure from a drawing by Mr. R. W. Matthews has been added to illustrate the Axillary Region and the Sterno-Clavicular Joint.

Several new radiographs (for which we are indebted to Dr. Robert McWhirter) have been added to the series of Plates; and new blocks have been made for others. There has been some rearrangement of the Plates; and some former Plates which were printed on text-pages in the Ninth Edition have been reinstated to permit the secure binding of all the Plates in the volumes.

As the Birmingham Nomenclature is now in common use in this country, the glossary at the beginning of each of the volumes in the Ninth Edition has probably served its purpose ; but we have retained it in Volume I for the convenience of those who may still wish to refer to it.

We are grateful to a number of friends and correspondents who have assisted us by making suggestions and by calling attention to discrepancies and omissions—especially to Dr. A. A. Abbie, Dr. G. I. Boyd, Mr. Lewis Graham, F.R.C.S., and Dr. W. F. Johnson of New York.

We owe thanks also to Emeritus-Professor Arthur Robinson, who has shown his continued interest by reading the proofs of all three volumes of this edition of the *Manual* of which he was the Editor for nearly half of its lifetime of fifty-one years. Some of our readers may be interested to note that the *Manual* reached the year of its Jubilee in 1939 —or Diamond Jubilee, if the years of its existence as a *Dissector's Guide* (1879–89) are included.

J. C. B.
E. B. J.

Department of Anatomy,
University of Edinburgh,
June 1940.

EXTRACTS FROM PREFACE TO THE NINTH EDITION

THE character of the book as a dissector's guide remains unaltered, but we have thought it advisable to make certain changes which we hope will bring the student's work in the dissecting-room into still closer relation with his study of the living body, and will further emphasise the kind of knowledge expected of him in his clinical work.

We have increased the stress laid on the importance of the relations of structures to the surface of the body, have reversed the relative emphasis laid on arteries and nerves and have given a fuller account of lymph-drainage. We have made more frequent reference to function and to the application of anatomical facts in the diagnosis and treatment of disease.

By referring to observations on the living body, we have also tried to correct the impressions of the form and position of viscera which the dissector obtains from the embalmed cadaver. Most of the illustrations of X-ray Anatomy have been replaced by radiographs in negative reproduction, such as the student sees in demonstrations and in clinical practice.

We are aware that our most important reader is the student who has not dissected the part before, and one of our aims has been to lighten his task. We have therefore given him, in Volume I., a General Introduction to the structures met with in a dissection, and, throughout, have striven to avoid putting information before him at a stage when he cannot understand it.

We have replaced the Basle Nomina Anatomica by the anglicised version of a revision of that nomenclature which was adopted by the Anatomical Society at Birmingham in 1933. The advantage of the use of this revision is twofold: it is accepted by all British teachers; and the anglicised form makes the text easier to read and more easily understood by the dissector—who is the reader for whom the book is primarily written. For the sake of those already familiar with the Basle terms, we have inserted a glossary of the names in the Birmingham Revision that differ radically from the B.N.A.

Most of the old illustrations have been retained unchanged, but a few have been omitted, some have been coloured, and others have been replaced; and a number of entirely new figures have been added.

J. C. B.
E. B. J.

DEPARTMENT OF ANATOMY,
UNIVERSITY OF EDINBURGH,
June 1935.

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MANUAL

OF

PRACTICAL ANATOMY

THORAX

INTRODUCTION

If the Thorax is the first part that the students dissect, they should read the General Introduction to Practical Anatomy in Vol. I., pp. 1-16 ; and, even if they have dissected a limb and have read those pages, they should re-read the paragraphs on the Nerves (pp. 8-11 in that volume) before they begin to dissect the Thorax, for branches of the typical examples of spinal nerves are encountered in the walls of the Thorax.

The Thorax is ready for dissection after the Upper Limbs have been removed from the trunk. The dissection may be begun then, but better access to the part is obtained after the dissectors of the other parts of the body have completed their work.

Before actual dissection is begun, the students should acquire some preliminary information about the principal organs of respiration, should take note of the shape of the thorax, should examine the framework of its walls, and should study the principal movements that take place during respiration.

Chief Organs of Respiration.—The purpose of the movements of the chest-wall in respiration is to draw air into the lungs and to drive it out again. The **lungs** (pulmones) are a pair of organs that occupy the greater part of the interior of the chest. They resemble a sponge—an innumerable multitude of small cavities with thin walls—and they are very distensible and very elastic. The cavities within them are in free communication with the exterior through the air-passages, namely :—(1) the *nose* and the *mouth* ; (2) the *pharynx* or throat ; (3) the *larynx* or voice-box ; (4) the *trachea* or wind-pipe ; and (5) a pair of tubes called the *bronchi* into which the trachea divides. Each bronchus enters a lung and breaks up into a large number of air-tubes within it.

Each lung has a blunt, rounded *apex* above (Fig. 20), a wide, concave *base* below, a convex *lateral* or *costal surface*, and an uneven *medial surface* (Fig. 22). The surfaces meet in front at a well-defined, sharp *anterior border* ; and, behind, they are confluent with each other over a very indistinct *posterior border* at the thickest part of the lung.

The bronchus enters the lung at the centre of its medial surface, and is accompanied by the *pulmonary vessels* and *nerves*. Collectively, these structures are called the *root of the lung*, and they connect the lung with other structures—chiefly the trachea and the heart. The place where they enter is called the *hilum of the lung*.

To lessen friction during the movements of respiration, a serous membrane is provided—*i.e.* a thin membrane whose free surface is smooth and glistening and is moistened with serum or lymph. This membrane is called the **pleura** (Fig. 5). It was originally a simple closed bag or sac ; but, during development, the lung, as it grew, invaginated the pleural sac from the medial side so that it comes to have two layers which are continuous with each other around the root of the lung. The inner layer covers the lung and adheres to the pulmonary substance, and is called the *pulmonary pleura* ; the outer layer is called the *parietal pleura* because it lines the parietes or walls of the space in which the lung lies. The cavity of the sac, between the two layers of the pleura, is a mere capillary interval occupied by the film of lymph that keeps their smooth surfaces moist and enables them to glide easily over each other.

Shape and Framework of Thorax.—The **form** of the thorax is that of a truncated cone, flattened in front and behind but rounded at the sides.

The **framework** of the walls should be studied on the skeleton as well as on the part. It is formed *anteriorly* by the sternum and the costal cartilages; *posteriorly* by the bodies of the twelve thoracic vertebræ and the corresponding intervertebral discs, and by the ribs, from their heads to their angles; and *on each side* by the shafts of the ribs, from their angles to their cartilages.

The anterior wall is so much shorter than the posterior wall that, during expiration, the upper margin of the sternum is opposite the disc between the second and third thoracic vertebræ, and the xiphi-sternal joint is opposite the ninth or the tenth thoracic vertebra (Fig. 6).

The bodies of the thoracic vertebræ project forwards and greatly diminish the antero-posterior diameter of the cavity

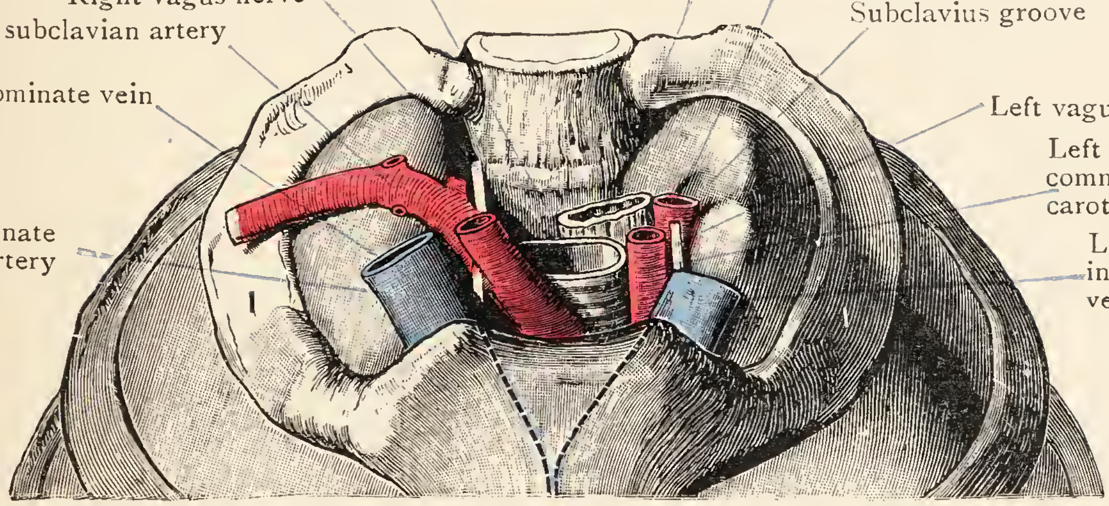


FIG. 1.—Inlet of Thorax and its Principal Contents

in the median plane; but the backward sweep of the posterior parts of the ribs produces a deep hollow on each side of the vertebral column for the reception of the most massive part of the corresponding lung (Fig. 5).

Inlet and Outlet.—The **inlet** of the thorax (Fig. 1) is a narrow opening which is bounded by the body of the first thoracic vertebra, the first pair of ribs and the upper border of the manubrium sterni. The plane of the inlet slopes very obliquely downwards and forwards, so that the anterior part of the apex of the lung is above the level of the anterior boundary of the inlet, though its posterior part only attains the level of the neck of the first rib (Fig. 1).

The structures which enter or leave the thorax through the inlet are:—the trachea; the œsophagus or gullet; two pairs of nerves called the vagus and the phrenic; the left recurrent laryngeal nerve; the thoracic duct; and the great arteries and veins which carry blood to and from the head and neck and upper limbs.

The **outlet** of the thorax is much larger than the inlet. It is bounded by the xiphi-sternal joint, by the lower six costal cartilages and the twelfth rib, and by the twelfth thoracic vertebra; and the boundary or margin is curved, for it descends to the tip of the eleventh costal cartilage and then ascends.

The inner aspect of the lower margin of the thorax gives attachment to the *diaphragm*—a highly vaulted or dome-shaped, musculo-tendinous partition which intervenes between the cavities of the thorax and abdomen, forming a convex floor for the thorax and a concave roof for the abdomen. By its upward bulging it greatly diminishes the vertical diameters of the thorax (Figs. 13, 14, 15, 16); and the result of this arrangement is that the margin of the lower part of the thorax overlaps the upper part of the cavity of the abdomen, especially at the sides and behind.

The diaphragm, however, is not an unbroken partition. There are three large openings in it through which structures pass between the thorax and the abdomen, viz., aortic, œsophageal, and vena caval. The *aortic opening* transmits:—the great artery called the aorta as it descends from thorax to abdomen; the thoracic duct—the chief lymph-vessel of the body—ascending from abdomen; and a vein named the vena azygos, also ascending from abdomen. The *œsophageal opening* transmits the œsophagus and two small but important nerves of the stomach called the gastric nerves. The *vena caval opening* transmits the largest vein in the body—the inferior vena cava. In addition, there are smaller apertures that transmit structures which will be mentioned later.

Movements in Breathing.—Throughout life, the movements of the thoracic wall produce the alterations in the size of the thoracic cavity which are essential for respiration. During inspiration—that is, when a breath is taken—the cavity is enlarged; during expiration the cavity is diminished. (Figs. 8 and 24).

There are *two types of respiration*: *thoracic* and *abdominal*.

In *thoracic inspiration*, the sternum and the anterior parts of the ribs move upwards and forwards, with the result that the antero-posterior diameters of the thoracic cavity are increased. At the same time, on account of the peculiarities of the articulations of the ribs, the lower borders of the majority of the ribs rotate outwards, and the transverse diameter of the cavity is thus enlarged. In thoracic inspiration, the cavity of the thorax is increased therefore both antero-posteriorly and transversely.

In *abdominal inspiration*, the vertical diameters of the thoracic cavity are increased by the contraction of the diaphragm. The central part of its dome is tendinous and remains relatively stationary, but the muscular, peripheral parts contract. As they contract, they pass from a more curved to a less curved form, and press down the contents of the abdomen so that the abdominal wall bulges forwards.

As the larger part of the floor of the thorax is thus depressed, the greater part of the thoracic cavity is increased in height, but its antero-posterior and transverse diameters remain unchanged.

Since the cavity of the thorax is completely enclosed, an increase of its capacity tends to produce a vacuum in its interior; but neither the diaphragm nor the muscles which raise the ribs and sternum are competent to produce such a vacuum—a fact which the dissector can demonstrate by breathing out, closing the mouth and nose and then attempting to draw in a breath.

Under ordinary circumstances, however, as the cavity of the thorax enlarges, atmospheric pressure (15 lb. to the square inch) forces air through the air-passages into the lungs, enlarging them at the same rate, so that they fully occupy the expanding space.

When the contraction of the muscles which raise the ribs and sternum ceases, *thoracic expiration* begins. The weight of the thoracic wall, the resilience of the costal cartilages and the elasticity of the ligaments reduce the cavity to its original size; and air is expelled from the lungs. Similarly, in *abdominal expiration*, when the diaphragm ceases to contract, the abdominal contents are pressed upwards by the elastic recoil of the muscles of the abdominal wall; the height of the thoracic cavity is thus reduced, and air again is expelled.

Abdominal and thoracic respiration are initiated and controlled by different groups of muscles, and they may take place independently of each other or may to a certain extent be combined. They should be studied by the student both on himself and on the living model.

It is commonly stated that abdominal respiration predominates in the male, and thoracic in the female; and it will be readily understood why respiratory movements in the female become almost wholly thoracic in the later months of pregnancy.

WALLS OF THORAX

Two days at least should be devoted to the dissection of the thoracic walls.

In addition to the osseous and cartilaginous framework, the walls of the thorax are built up partly of muscles and partly of membranes; and associated with these structures there are numerous nerves and blood-vessels.

Muscles	External intercostals.	
	Internal intercostals.	
	Transversus thoracis	Sterno-costalis.
		Intercostales intimi.
		Subcostales.
Membranes	Anterior intercostal membranes.	
	Posterior intercostal membranes.	
	Pleura (parietal layer).	
Nerves and Blood-vessels	Intercostal nerves.	
	Intercostal vessels.	
	Internal mammary vessels.	

Superficial Structures.—In the Thorax, the branches of spinal nerves which reach the skin are :—(1) the cutaneous branches of the posterior primary rami of the thoracic nerves; and (2) the lateral cutaneous branches and the anterior cutaneous branches of the anterior primary rami—these anterior rami being the *intercostal nerves*.

The cutaneous branches of the posterior rami have already been removed by the dissectors of the Limbs, but the dissectors of the Thorax will find remnants of the lateral and anterior cutaneous branches of the intercostal nerves issuing between the ribs on the side and the front of the thorax.

Identify the structures that have been left on the thoracic wall by the dissectors of the Upper Limb and the Abdomen, viz. :—(1) portions of certain muscles; (2) the lateral cutaneous nerves; and (3) the upper six anterior cutaneous nerves accompanied by the perforating branches of an artery named the internal mammary, which descends behind the upper six costal cartilages.

The remnants of muscles to be examined are, from before backwards :—the *pectoralis major*, attached to the sternum

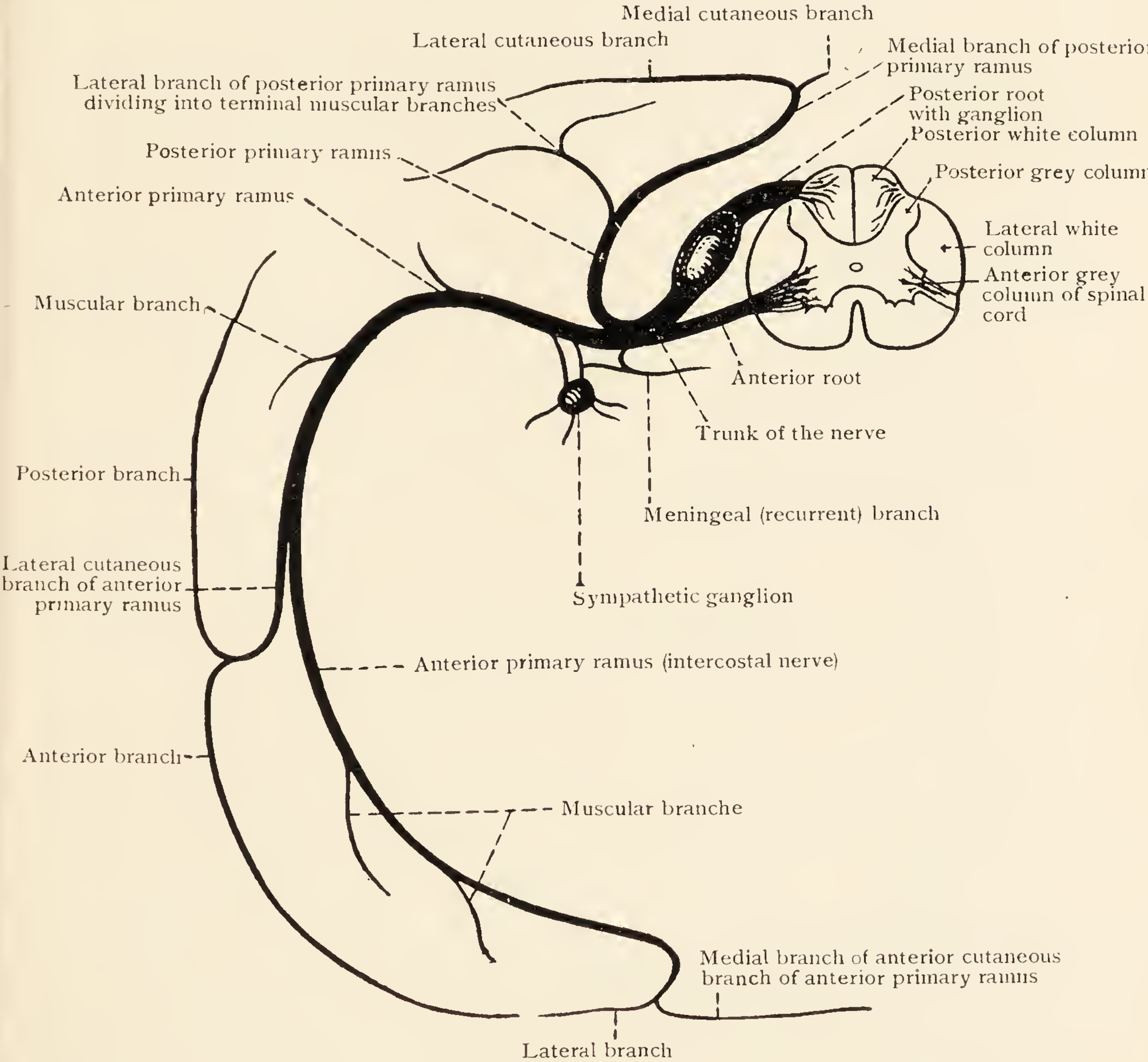


FIG. 2.—Diagram of a Typical Spinal Nerve. Note that the medial branch of the posterior primary ramus is represented as distributed to skin, whilst the lateral branch terminates at a deeper level in muscle. Both branches, however, supply muscles ; and in the lower half of the body it is the lateral branch that supplies skin.

and the cartilages of the upper six ribs ; the *pectoralis minor*, attached to the third, fourth and fifth ribs neaı their cartilages ; and the *serratus anterior*, attached to the upper eight or nine ribs along a curved line on the side of the thorax. Towards the lower margin of the chest there are, in addition :— the *rectus abdominis*, attached to the xiphoid process and the cartilages of the seventh, sixth and fifth ribs ; the *obliquus* *externus abdominis*, attached to the lower eight ribs, interdigitating with the serratus anterior and the latissimus dorsi; and the *latissimus dorsi*, attached to the lowest three or four ribs.

The *anterior cutaneous nerves* and the *perforating branches of the internal mammary artery* will be found piercing the pectoralis major at the sternal ends of the intercostal spaces. The *lateral cutaneous nerves* appear between the digitations of the serratus anterior and obliquus externus a little in front of the mid-axillary line.

Dissection.—Remove the remnants of the muscles so as to lay bare the costal arches and the external intercostal muscles and membranes, but preserve the cutaneous nerves and the accompanying vessels. Clean the *external intercostal muscles*, which lie between the ribs, and the *anterior intercostal membranes*, which occupy the same plane between the costal cartilages.

Intercostal Muscles and Membranes.—In each intercostal space there are two strata of muscular fibres—a superficial and a deep, named the *external* and the *internal intercostal muscle*.

The **external intercostal muscle** is composed of intermingled muscular and tendinous fibres which are directed obliquely downwards and forwards from the lower border of the rib above to the upper border of the rib below. The muscle does not extend farther forwards than the junction of the ribs with the costal cartilages; often, especially in the upper spaces, it does not reach so far. When the muscular fibres stop, the tendinous fibres are continued onwards to the sternum as the *anterior intercostal membrane*. The external intercostal muscles of the lower two spaces are exceptions to this rule: they extend forwards to the extremities of the spaces. Posteriorly, all the external muscles extend as far as the tubercles of the ribs; but that is a point which cannot be satisfactorily demonstrated at the present stage of dissection.

Dissection.—To bring the *internal intercostal muscles* into view, reflect the external intercostal muscles and the anterior intercostal membranes. Divide two or more of the muscles and membranes along the lower borders of their spaces and throw them upwards, but avoid injury to the intercostal vessels and to the lateral cutaneous branch of the intercostal nerve.

The **internal intercostal muscles**, now laid bare, will be seen to be similar in their structure to the external muscles. The fibres, however, run in the opposite direction—viz., from above downwards and backwards. Superiorly, each is attached to the inner surface of the upper rib immediately above the costal groove; inferiorly, it is attached to the inner surface of the lower rib close to the upper margin. The

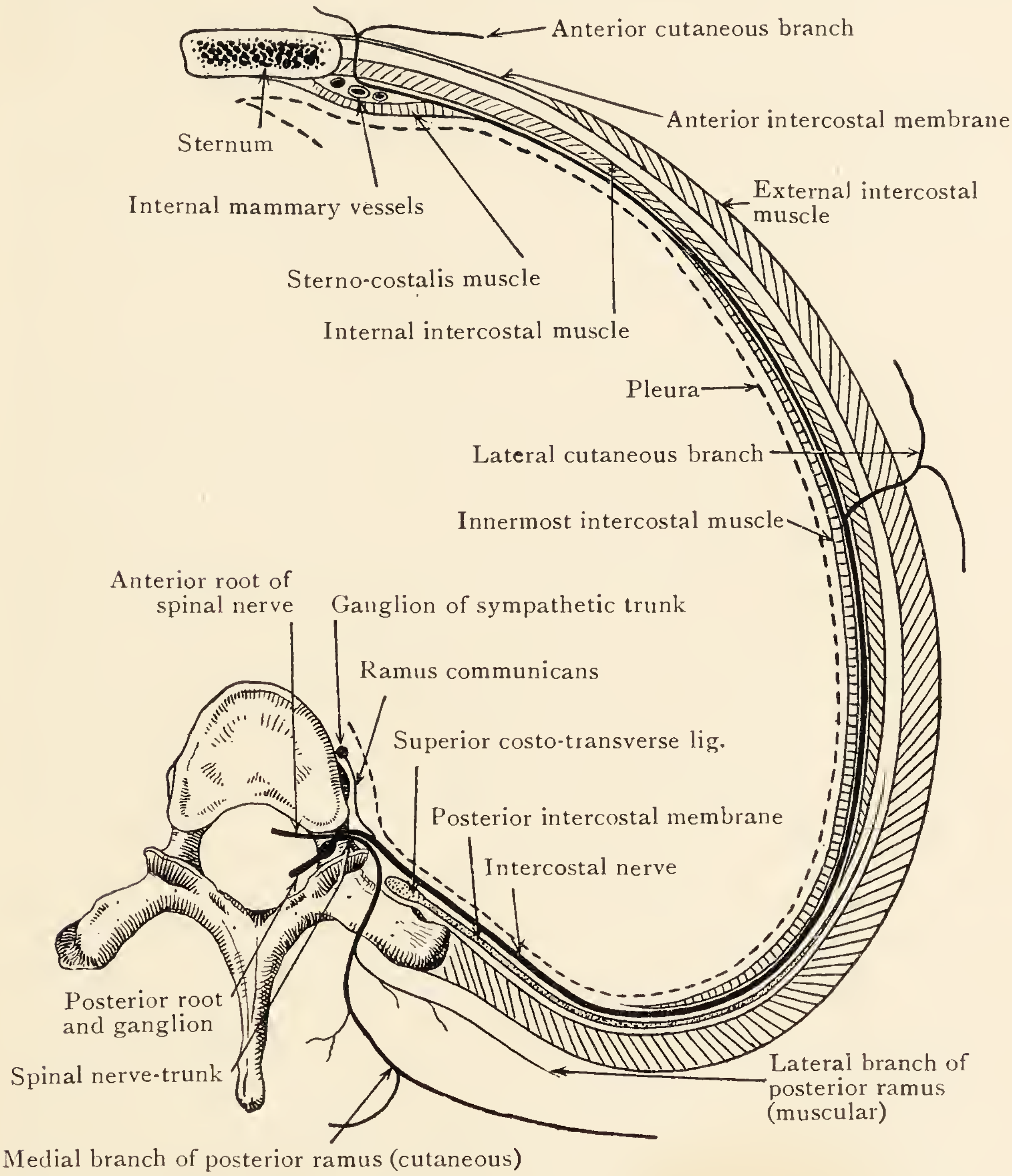


FIG. 3.—Diagram of Typical Spinal Nerve and Intercostal Space.

internal intercostal muscles reach the side of the sternum, but, posteriorly, they extend only to the angles of the ribs.

In a variable part of its extent the internal intercostal muscle is traversed by the intercostal nerve and vessels, and is partially divided by them into two layers. In some bodies a portion of the muscle is completely divided; the deeper layer is then called the *innermost intercostal muscle* (intercostalis intimus) (Fig. 3).

The *posterior intercostal membranes* extend from the vertebral column to the posterior borders of the internal intercostals; each then passes between the external and internal intercostal muscles, and soon blends with the fascia that separates them. They will be seen when the thorax is opened.

The lateral and anterior cutaneous branches of the intercostal nerves have already been found, but the main parts of the trunks of the nerves are concealed under cover of the lower borders of the ribs, and a little dissection is necessary to expose them and the intercostal arteries and veins, which lie at still higher levels under cover of the ribs.

Dissection.—Dissect the *intercostal nerves and vessels* in two or three spaces. If the arteries are not injected it may be difficult or impossible to display them in the anterior parts of the spaces, but they will easily be found later in the posterior parts of the spaces after the thorax is opened. Follow the lateral cutaneous branch of an intercostal nerve, preferably that of the third, fourth or fifth, to the lower border of the rib, where it will serve as a guide to the trunk of the nerve; and cut away the lower border of the rib with bone-forceps until the origin of the cutaneous branch from the nerve-trunk is found. Follow the trunk backwards as far as possible, removing the part of the rib which covers it, and, at the same time, clean the intercostal vessels, if they can be found. Next, trace the nerve and artery forwards, and note the branches of the nerve to the intercostal muscles. If one of the lower six intercostal nerves is followed, it will be found to pass into the abdominal wall, where it has been traced by the dissectors of the Abdomen.

Intercostal Nerves.—These nerves are the anterior primary rami of the upper eleven thoracic nerves; and they are connected with a gangliated nerve-cord called the sympathetic trunk, which descends from the neck and lies in relation with the sides of the bodies of the thoracic vertebræ.

Course and Relations.—Each intercostal nerve, on emerging from the intervertebral foramen, sends forwards a *white ramus communicans* to a ganglion of the sympathetic trunk, and receives a *grey ramus communicans* from it (Figs. 17, 18). The nerve then enters the vertebral end of the corresponding intercostal space, and runs onwards in it. At first, it is between the pleura and the posterior intercostal membrane; but, near the angle of the rib, it slips in between the external and internal intercostal muscles, and shortly afterwards it enters the substance of the internal muscle. It passes through that muscle very gradually, and emerges on its deep surface near the junction of a rib with its cartilage. Having escaped from the internal muscle, it runs medially between that muscle and the pleura—partially separated from the pleura by the sterno-costalis muscle (Fig. 4). About half an inch from the sternum, it crosses in front of the internal mammary vessels ; it then turns forwards, and, after piercing the internal intercostal muscle, the anterior intercostal membrane, the pectoralis major muscle, and the deep fascia, it enters the superficial fascia as an anterior cutaneous nerve. After the thorax is opened, it will be seen that the intercostal nerve, as it enters the intercostal space, crosses behind the intercostal vessels, and thereafter lies immediately below them. As far as the angle of the rib, the nerve and vessels lie below the rib and are accessible by dissection from the back ; in the side of the chest, they lie under shelter of the lower part of the rib.

This description applies wholly to the nerves from the second to the sixth only. The first nerve runs the early part of its course on the pleural surface of the first rib ; and it is above the level of the sterno-costalis. The lowest five, having reached the deep surface of the internal intercostal muscles, pass from the intercostal spaces into the wall of the abdomen —the upper three of them passing behind the upturned parts of the costal cartilages. The further course of these five nerves has been traced by the dissectors of the Abdomen (p. 197).

Branches.—The branches of an intercostal nerve are :—(1) rami communicantes, which connect it with the sympathetic trunk ; (2) a collateral branch ; (3) lateral and anterior cutaneous branches ; (4) muscular branches.

The rami communicantes have been referred to already (p. 10).

The *collateral branch* arises near the angle of the rib, runs along the upper border of the rib below, and supplies intercostal muscles. It is not always present, and, when present, it may rejoin the main stem.

The *anterior cutaneous branch* is the terminal filament which divides to supply the skin on the front of the trunk.

The *lateral cutaneous branch* is a large branch—thicker than the continuation of the parent nerve. It arises at a variable point beyond the angle of the rib. About half-way round the chest, it pierces the external intercostal muscle, and, according to its position, passes between the digitations of either the serratus anterior or the external oblique muscle ; it then divides into an anterior and a posterior branch which are distributed to the skin of the side of the trunk. The lateral cutaneous branch of the first intercostal nerve, though said to be constant (Cave), is seldom found, and its anterior cutaneous branch is often absent. The lateral cutaneous branch of the second is distributed to the upper arm as the *intercosto-brachial nerve.* Twigs to the external oblique muscle of the abdomen spring from the lower members of the series.

The *muscular branches* of the intercostal trunk are:— (1) twigs to the *intercostal* muscles from each; (2) twigs to the *subcostal* muscles (p. 37) from a variable number, and to the *sterno-costalis* (p. 16) from the second, third, fourth, fifth and sixth; (3) a twig from each to a *levator costæ*, twigs to the *serratus posterior superior* from the upper three, and to the *serratus posterior inferior* from the lower three (these are muscles of the back which are displayed by the dissectors of the Head and Neck); (4) to the *transversus* and *rectus abdominis* and the *external* and *internal oblique* muscles of the abdomen from the lower five.

Intercostal Arteries.—In each intercostal space *one* posterior intercostal artery runs from behind forwards; and in each of the upper nine spaces *two* anterior intercostal arteries run laterally. The posterior intercostal arteries of the uppermost two spaces are derived from the *superior intercostal* branch of the costo-cervical trunk, which springs from the subclavian artery in the root of the neck; those in the lower nine spaces spring from the *descending aorta*—that is the great artery that runs downwards in close relation to the bodies of the vertebræ. The anterior intercostal arteries of the upper six spaces are branches of the *internal mammary* artery; and those of the seventh, eighth and ninth spaces arise from the *musculo-phrenic* artery, which is one of the two terminal branches of the internal mammary artery. The last two spaces do not reach far enough forwards to require anterior intercostal arteries.

A *posterior intercostal artery* runs along an intercostal space above the nerve and below its companion vein. A little beyond the angle of the rib, it gives off a *collateral branch*, which runs along the upper border of the rib below; and near the same point a slender branch leaves it to accompany the lateral cutaneous nerve. The main trunk and the collateral branch end anteriorly by anastomosing with the two anterior arteries of the space, except in the lower two spaces, where they run on into the wall of the abdomen.

The *anterior intercostal arteries* are two in number for each of the upper nine spaces. At their origin they lie under cover of the internal intercostal muscle, and they run laterally in relation to the upper and lower margins of the cartilages that bound the spaces. After a short course they pierce the internal intercostal muscle, and end by anastomosing with the posterior intercostal artery and its collateral branch.

The **anterior intercostal veins** accompany the corresponding arteries ; the lower ones end in the musculo-phrenic vein, and the upper in the venæ comitantes of the internal mammary artery.

The veins which accompany the posterior intercostal arteries will be traced to their terminations after the thorax has been opened (see pp. 33, 128).

Dissection.—Remove the intercostal muscles and membranes from the upper six intercostal spaces. Do this with great care, for the *parietal pleura* is immediately subjacent to the internal intercostals and the ribs, and must not be injured or detached from the ribs at this stage. As the internal intercostal muscles are removed, preserve the *anterior cutaneous nerves* and the *perforating arteries*.

When the muscles have been removed, the *internal mammary vessels* are seen about half an inch from the side of the sternum (Figs. 4, 34). Clean these vessels in the intercostal spaces, noting the small *internal mammary lymph-glands* which lie beside them ; and follow the artery to the interval between the sixth and seventh rib cartilages, where it ends by dividing into two branches. If that space is so narrow that the bifurcation cannot be seen, pare away the edges of the cartilages or remove a portion of the sixth cartilage completely. Define the slips of the *sterno-costalis* in the intervals between the costal cartilages.

Relation of Lower Intercostal Muscles to Diaphragm.—Before proceeding to remove the muscles from the lower five spaces, note, as an important practical point, that, at the side of the chest, the pleural sac does not reach the lowest limit of the recess between the diaphragm and the costal arches (Fig. 13). Consequently, when the internal intercostal muscles are removed from the anterior parts of the lower intercostal spaces, the dissectors will come down directly upon the diaphragm (Fig. 13) ; and it is no uncommon occurrence for a student to remove part of it with the intercostal muscles and thus expose the peritoneum, under the impression that he has laid bare the pleura.

> ***Dissection.***—**Remove the contents of the lower five intercostal spaces, carefully avoiding injury to the diaphragm. At the same time, define the lower margin of the pleura—beginning anteriorly and tracing it backwards. While doing so, try to preserve a thin fibrous band, called the *phrenico-pleural fascia*, which binds the lower edge of the pleura to the diaphragm.**

Phrenico-Pleural Fascia.—This is a thin, narrow ribbon of fibrous tissue that lies along the lower edge of the pleura, binding it to the diaphragm and adjoining ribs and costal cartilages ; it keeps the pleura in place during the movements of the chest-wall and the diaphragm.

Internal Mammary Artery.—This artery arises in the root of the neck from the first part of the subclavian artery and enters the thorax by passing downwards behind the clavicle and the cartilage of the first rib ; it then descends to the interval between the sixth and seventh costal cartilages, and ends behind that interval by dividing into the *superior epigastric* and *musculo-phrenic arteries* (Figs. 4, 34).

Relations in Thorax.—In front of the internal mammary artery there are the upper six costal cartilages, with the intervening internal intercostal muscles and anterior intercostal membranes. The intercostal nerves cross anterior to it before they turn forwards to gain the surface. The pleura is behind the upper part of the artery ; but the sterno-costalis intervenes between it and the lower half of the artery.

Branches.—In addition to its two terminal branches, the internal mammary artery gives off a large number of small branches to the thoracic wall and to parts in the interior of the thorax. These include arteries that have been seen already—the *anterior intercostal arteries* to the upper six spaces and the *perforating arteries*, which accompany the anterior cutaneous nerves. The name of the main artery is derived from the fact that the perforating arteries of the second, third and fourth spaces attain a special importance in the female as arteries of supply to the mammary gland.

The *superior epigastric artery* passes between the sternal and costal origins of the diaphragm and enters the sheath of the rectus muscle of the abdominal wall.

The *musculo-phrenic artery* turns laterally and downwards, along the costal origin of the diaphragm and behind the rib-cartilages. Opposite the eighth costal cartilage it pierces the diaphragm and terminates on its abdominal surface. It gives off the *anterior intercostal arteries* to the seventh, eighth and ninth intercostal spaces.

Internal Mammary Vein.—This vein is formed behind the third costal cartilage by the junction of the two venæ comitantes that accompany the internal mammary artery in the

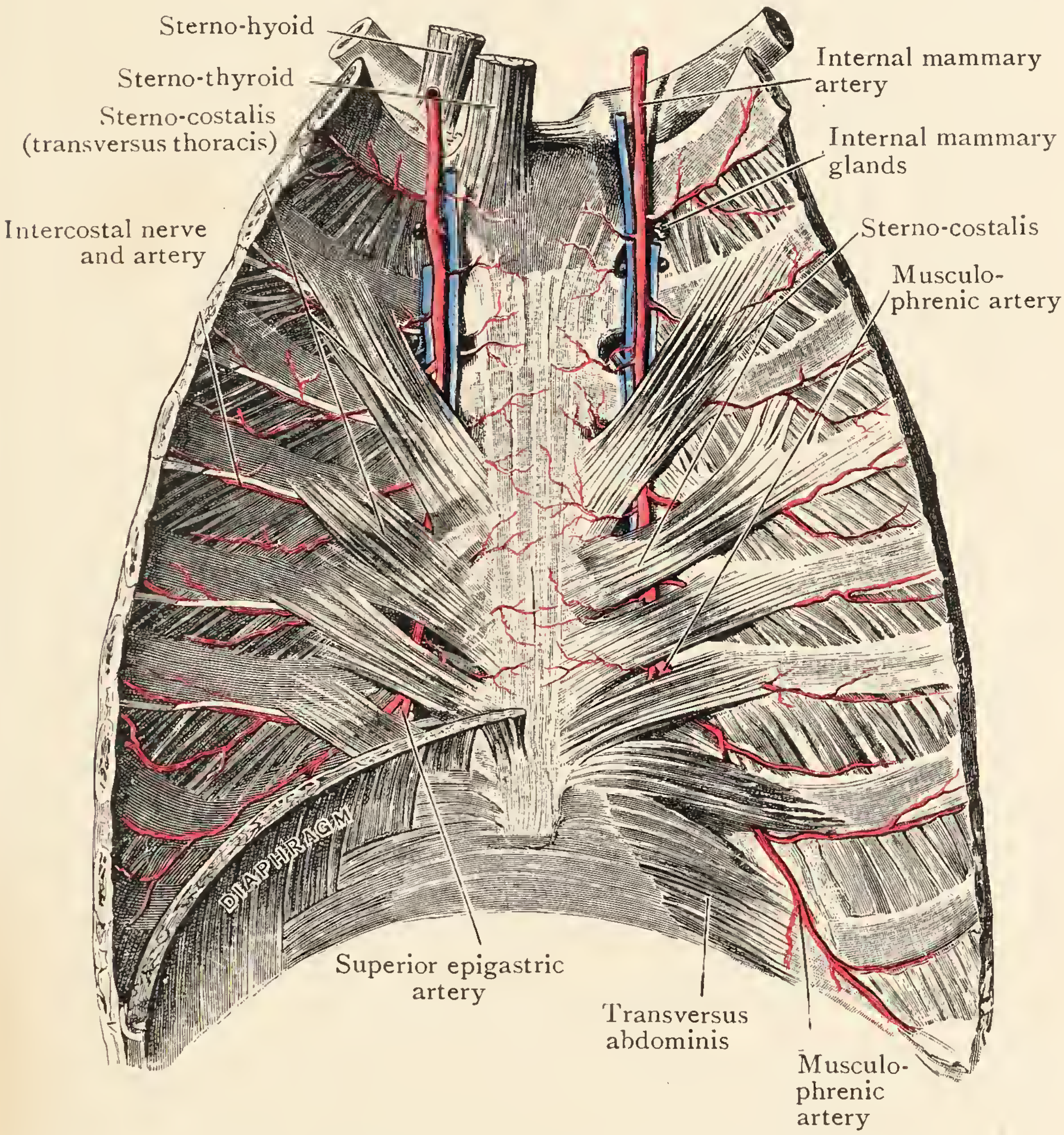


FIG. 4.—Dissection of Posterior Surface of Anterior Wall of Thorax.

greater part of its course; and, at the inlet of the thorax, it ends in a large vessel called the innominate vein (see p. 62 and Figs. 4, 34).

Transversus Thoracis.—The transversus thoracis is a compound muscle which lies in the same plane as the transversus abdominis. It is made up of three more or less distinct parts which form an incomplete, thin muscular layer placed on the deep surface of the sternum, the costal cartilages and the ribs. The three parts are the sterno-costalis, the innermost intercostals and the subcostals.

The **sterno-costalis** is the principal part of the transversus thoracis, and is directly continuous below with the transversus abdominis. Its four or five slips, which may be very feebly developed, arise from the back of the xiphoid process, the lower part of the body of the sternum and the medial ends of adjacent costal cartilages, and pass laterally and upwards to be inserted into the second, third, fourth, fifth and sixth costal cartilages close to their junction with the ribs (Fig. 4). It is supplied by the second, third, fourth, fifth and sixth intercostal nerves ; and it has a feeble depressing action on the anterior parts of the ribs.

Only a partial view of the muscle is obtained in the present dissection ; but do not remove the costal cartilages to expose it further, as that would interfere with the subsequent display of the relations of more important structures.

The **subcostal muscles** will be examined at a later stage of the dissection.

The *innermost intercostal muscles* (intercostales intimi) have been mentioned already (p. 9) as the deeper layer of the internal intercostal muscles.

CAVITY OF THORAX

Before the dissectors begin to examine the interior of the thorax, they should have some general knowledge of the contents of the cavity, which, in the first place, is completely divided into a right and a left lateral part by a thick (and more or less median) partition called the *mediastinal septum*.

Mediastinum.—The mediastinal septum is made up of a large number of structures embedded in areolar tissue, and the space occupied by the septum is known as the *mediastinum*. The structures in the septum are :—

The heart, enveloped in a sac called the pericardium.
The aorta and the other great vessels that leave and enter the heart.
The branches of the arch of the aorta.
The innominate veins.
The œsophagus.
The trachea and the commencement of the bronchi.
The thoracic duct.
The azygos vein, and superior and inferior hemi-azygos veins.
The vagi and phrenic and cardiac nerves.
The remains of the thymus.
Numerous lymph-glands.

The areolar tissue ensheaths these structures and binds them together; but, as it is both yielding and elastic, it accommodates itself to the dilatation and contraction of the heart and blood-vessels.

To simplify the description of the contents of the mediastinum, we divide it into four parts:—(1) The *superior mediastinum* is the part above an imaginary plane that passes from the lower border of the manubrium sterni to the lower border of the body of the fourth thoracic vertebra, and separates the superior mediastinum from the other three mediastina.

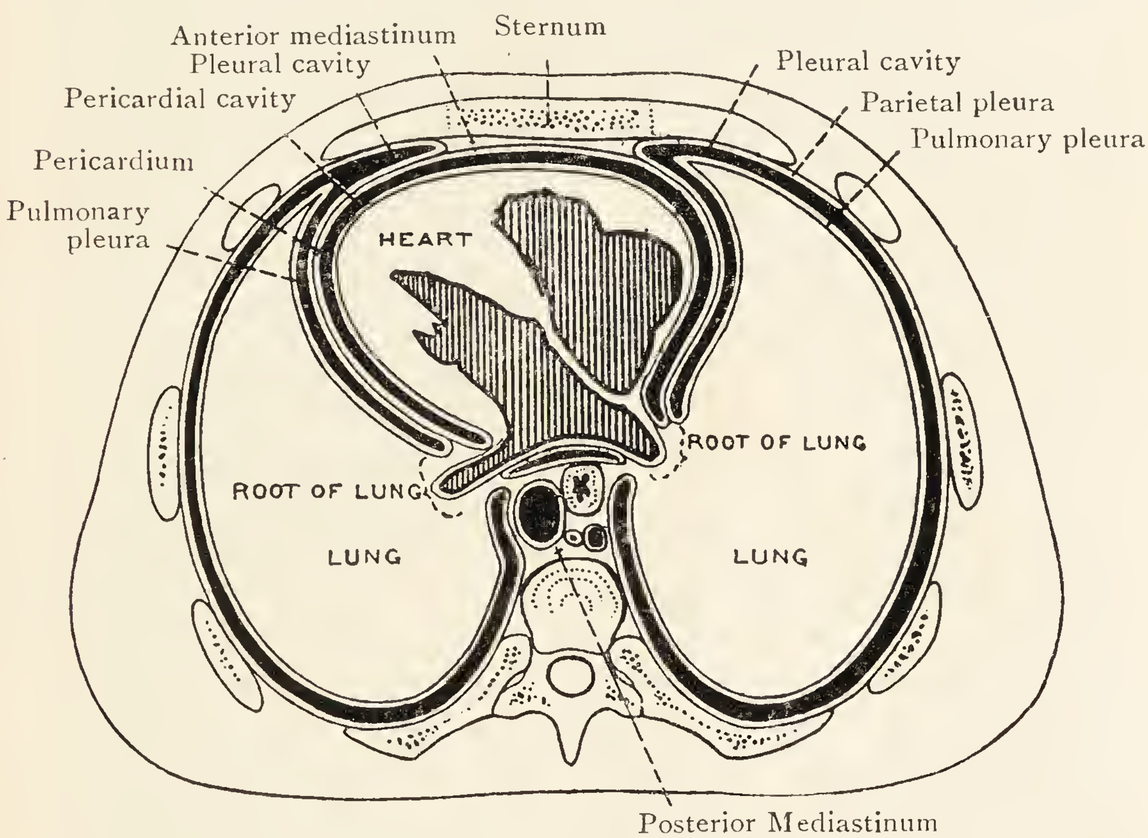


FIG. 5.—Diagram of Mediastinum in Transverse Section.
The heart and pericardium occupy the middle mediastinum.

(2) The *middle mediastinum* is the part occupied by the pericardium and its contents and the phrenic nerve on each side of it. (3) The *anterior mediastinum* is in front of the pericardium. (4) The *posterior mediastinum* is behind the pericardium and behind the diaphragm (Figs. 5, 6).

Lateral Parts of Thoracic Cavity.—These portions of the cavity are the chambers for the lungs; each of the chambers is lined with the parietal layer of the pleural sac, and is almost completely filled by the lung, which invaginates the sac from the mediastinal side (p. 2).

Each lung lies free in the pleural space, except along its medial surface, where it is attached to the bronchial tube, to the heart by the pulmonary vessels, and to the side of the

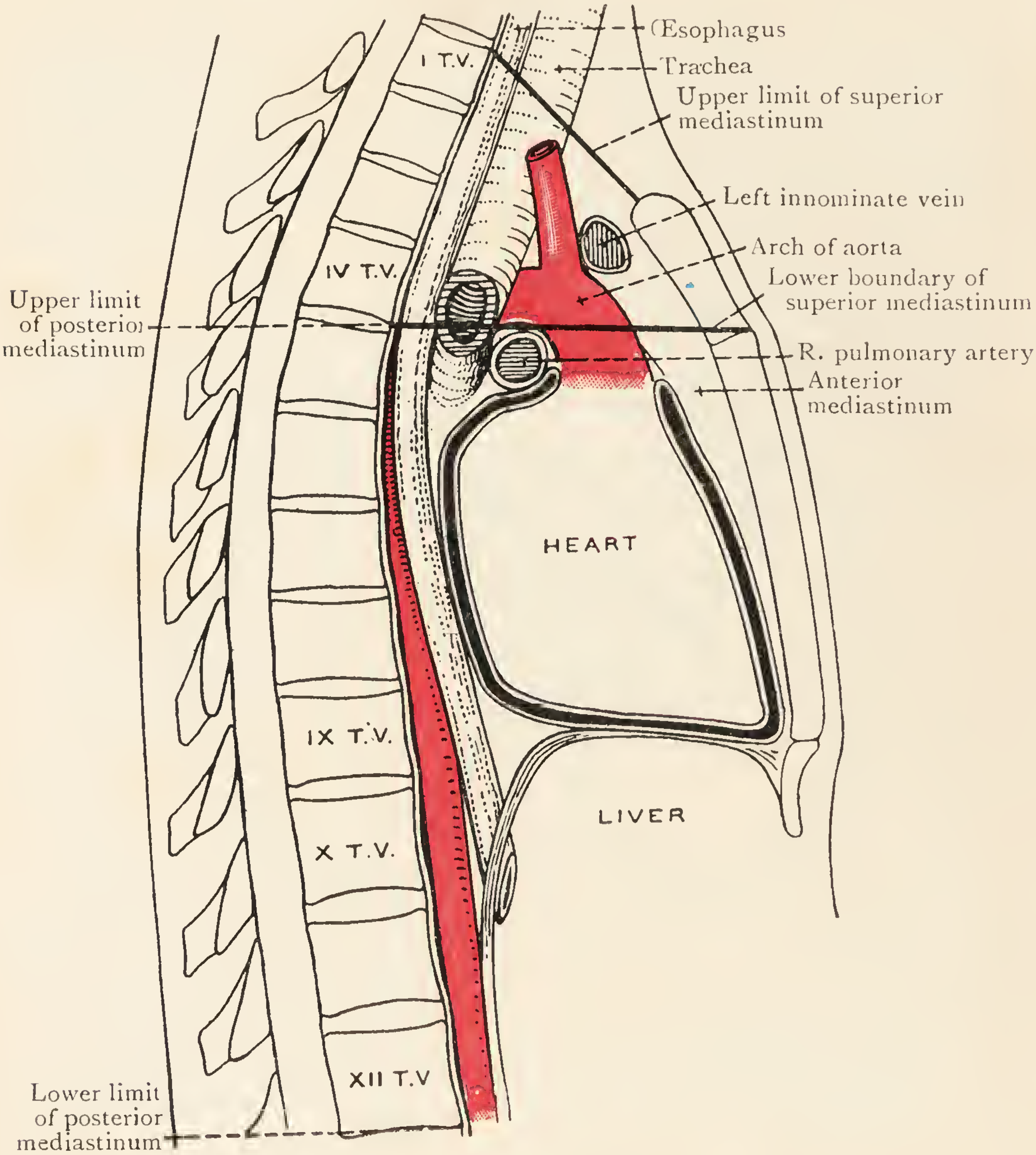


FIG. 6.—Diagram of Parts of Mediastinum in Median Section.

The heart and pericardium occupy the middle mediastinum. The pericardium forms the posterior boundary of the anterior mediastinum and part of the anterior boundary of the posterior mediastinum.

pericardium by a fold of pleura called the pulmonary ligament.

If the air was squeezed out of the lung, its actual bulk would not be nearly sufficient to fill the space which it normally occupies. Consequently, under normal conditions, the lung

PLATE I

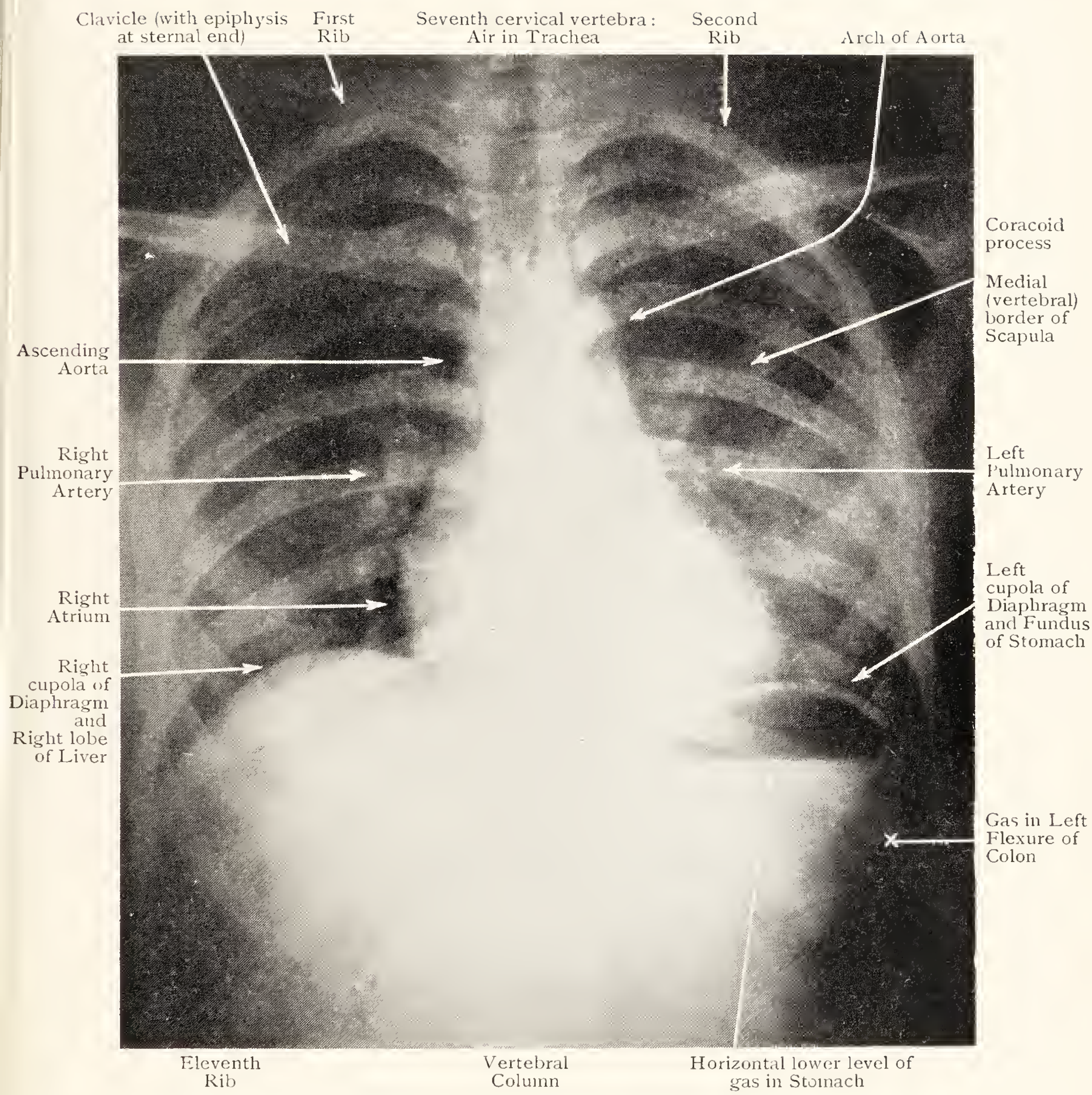


FIG. 7.—Radiograph of Thorax of youth aged 18, in position of Semi-Inspiration.

Compare with Figs. 8 and 24, noting the differences in level of the Diaphragm and in the shape of the Heart.

[Facing p. 18

the second to the eighth inclusive, as near their vertebral ends as possible, and remove them ; and *remove any sharp spicules of bone from the cut ends of the remaining portions.*

Now, divide the pleura by a vertical incision about midway between the borders of the area exposed. At each end of the vertical incision make a transverse incision—thus opening the pleural sac and exposing the lateral surface of the lung, covered with the pulmonary pleura.

Appearances of Pleura.—Note first that the outer surface of the parietal pleura has the appearance of a fibrous membrane with a rough surface, the roughness being due to fragments of the areolar tissue which connect it with the adjacent parts.

Note next that the inner surface of the healthy pleural membrane is smooth and glistening, and that the lung is everywhere free except at its root. Frequently, however, as the result of old inflammation, the pleura may be thickened and the pleural cavity obliterated by adhesions between the pulmonary and parietal layers of the membrane. It is sometimes necessary to break down extensive adhesions to free the lung.

Pulmonary Ligament.—Pass the fingers behind the sternum, find the anterior margin of the lung and pull the anterior part of the lung laterally. Now, run the fingers backwards over the middle part of the medial surface of the lung till they reach its root, and then look for a thin, narrow fold of pleura that extends downwards from the root.

That thin fold is the **pulmonary ligament.** It has an anterior and a posterior layer that correspond to the layers on the front and the back of the root of the lung, but come into contact with each other below the level of the root on account of the absence of the blood-vessels and bronchus. The ligament extends from the mediastinal septum to the medial surface of the lung, and from the root of the lung almost to the diaphragm. Its medial, lateral and upper borders are attached respectively to the mediastinal septum, the lung and the lower border of the lung-root, and are continuous with the pleura covering each ; but its lower border is free, and its two layers are continuous with each other at that border.

Continuity of Pleural Membrane traced Horizontally and Vertically.—In order to understand more fully the relationship of the pleura to other parts—lung, mediastinal septum, chest-wall, root of neck—examine the borders, surfaces and root of the lung, explore the cavity of the pleura with the fingers, and then, with the fingers, trace the pleura at three different levels—(1) at the level of the third intercostal space, (2) at the level of the fifth costal cartilage, and (3) at the level of the manubrium sterni. Trace the wall of the sac in the vertical plane also.

Beginning at the level of the third intercostal space, trace the deep surface of the anterior flap of the costal pleura to the back of the sternum, where the costal and mediastinal pleuræ are continuous with each other ; then, run the fingers backwards over the side of the mediastinal septum to the front of the root of the lung, and around the lung to the back of the root ; from that point, pass across the posterior part of the side of the mediastinal septum to the vertebral column and onwards to the ribs ; and, finally, forwards to the vertical incision in the costal pleura.

Now, trace the pleura in the same way at the level of the fifth costal cartilage—that is, below the level of the root of the lung, where the mediastinal pleura is connected with the pulmonary pleura by the pulmonary ligament. Then, trace it at the level of the manubrium sterni—that is, above the level of the root of the lung. There, the medial wall of the sac is not reflected on to the lung ; it passes backwards over the mediastinal septum from the sternum to the vertebral column, and thence first laterally and then forwards to the sternum, in an unbroken circle. In the same way, the dissector will be able to trace the pulmonary pleura in a similar but smaller unbroken circle around the upper part of the lung.

Next, trace the pleura in the vertical plane—first around the lung, and then around the wall of the thorax. Begin with the lung, and pass the fingers along the anterior border to the apex ; thence, down over the back of the lung to the base, and forwards across the base to the anterior border—again demonstrating the fact that the lung is ensheathed in pleura. Now, placing the fingers on the inner surface of the parietal pleura behind the costal cartilages, carry them upwards into the root of the neck, and then downwards over the posterior wall immediately lateral to the line of the vertebral column. If the body is in good condition, the fingers can be passed downwards to the lower border of the twelfth rib, where they will be carried forwards on to the diaphragm and over its surface to the anterior wall of the thorax. Note, along the line of the reflexion of the pleura from the thoracic wall on to the diaphragm, that the lower edge of the pleura is bound to the diaphragm by the *phrenico-pleural fascia* (p. 14).

If the dissector has appreciated the significance of the arrangements found at different levels, he will have convinced himself that the lung, carrying the blood-vessels and air-tube

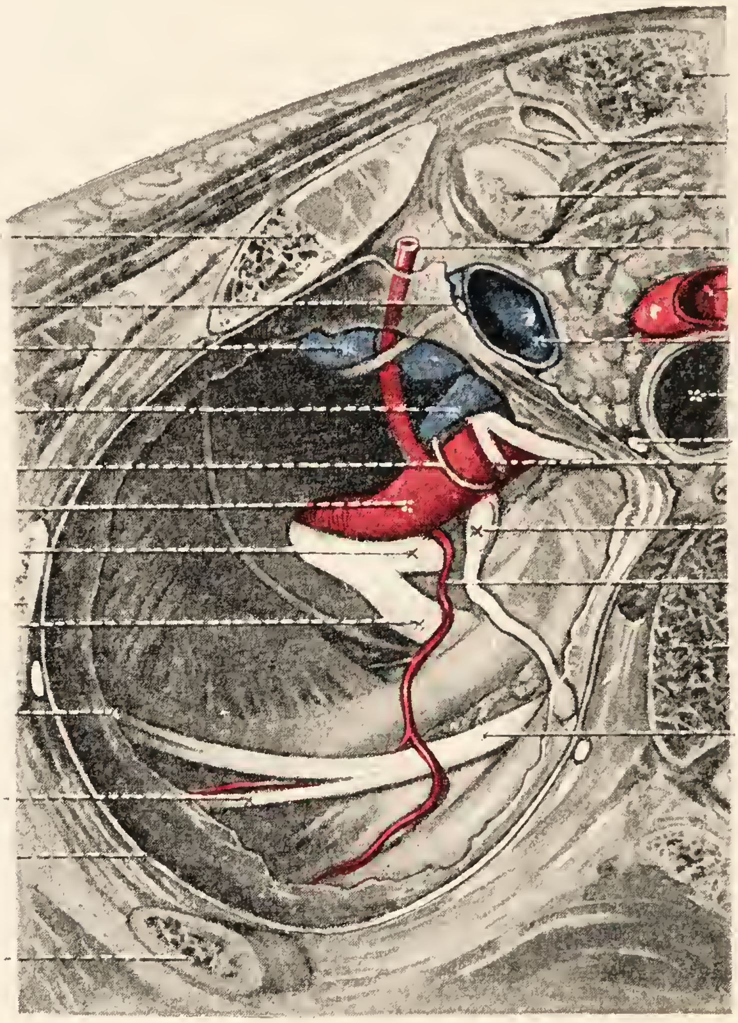


FIG. 9.—Structures in relation with Apex of Pleural Sac, seen from below.

with it, has during its development invaginated a portion of the lower part of the medial wall of the pleural sac, and has then expanded forwards, backwards, upwards and, to a certain extent, downwards, beyond the margins of the aperture of invagination—the position of the aperture being indicated by the root of the lung and the line of attachment of the pulmonary ligament.

Position of Cervical Pleura.—Return to the apex of the pleural sac, and push the fingers up into it. They pass upwards into the root of the neck for one or two inches above the level of the anterior part of the first rib, but only to the level of its neck posteriorly, because of the obliquity of the rib. By careful palpation, the dissector will be able to feel the *subclavian artery,* which arches across the front of the cervical

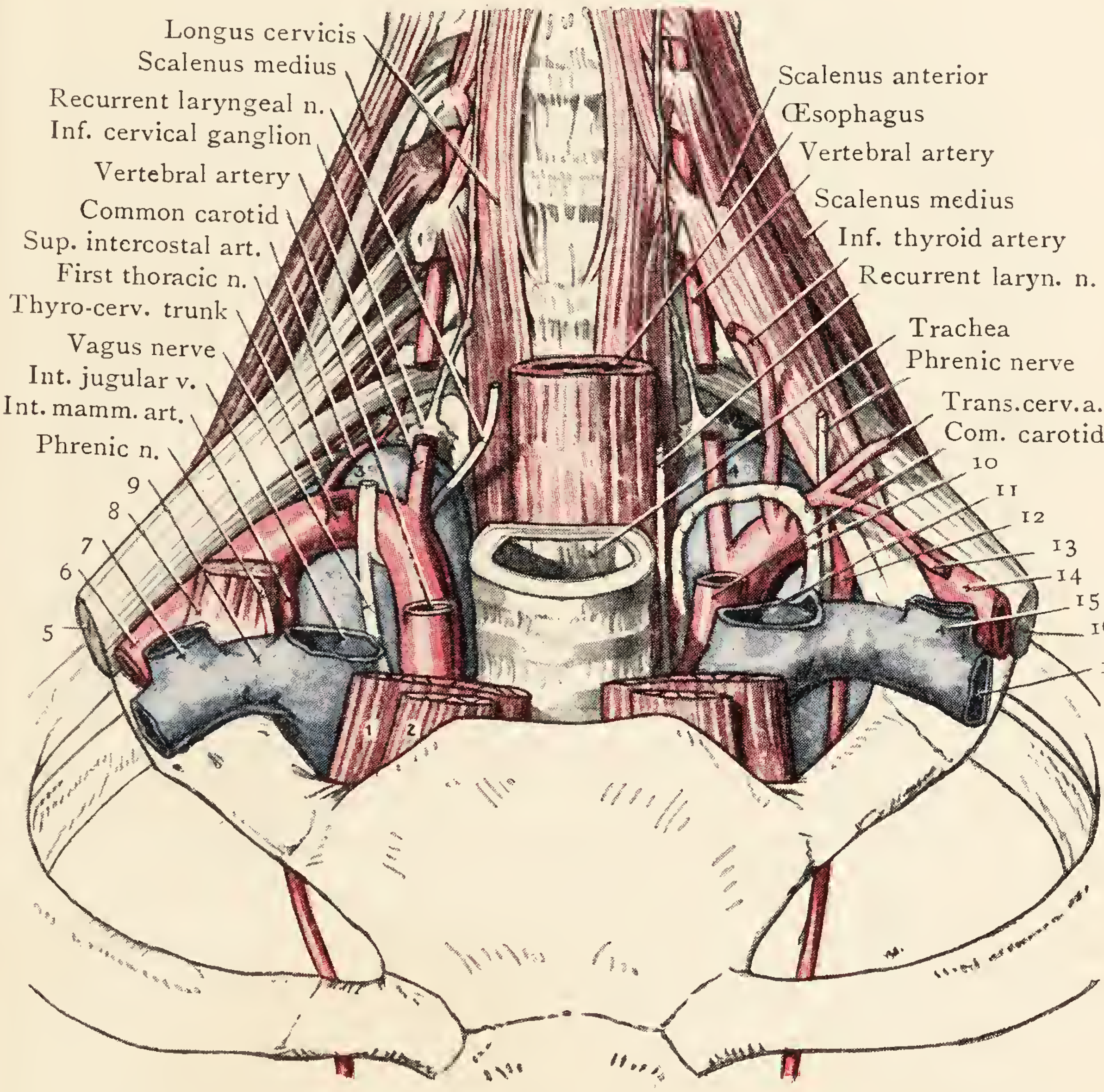


FIG. 10.—Dissection showing the Relations of the Cervical Pleura (semi-diagrammatic).

1. Sterno-thyroid.
2. Sterno-hyoid.
3. Apex of right pleural sac.
4. Apex of left pleural sac.
5. Brachial plexus.
6. Subclavian artery.
7. External jugular vein.
8. Scalenus anterior.
9. Subclavian vein.
10. Thoracic duct.
11. Internal jugular vein.
12. Internal mammary artery.
13. Suprascapular artery.
14. Subclavian artery.
15. External jugular vein.
16. Brachial plexus.
17. Subclavian vein.

pleura a little below its highest point ; and possibly he may feel its internal mammary and costo-cervical branches (Fig. 7). The *internal mammary artery* descends from the subclavian in front of the pleura. The *costo-cervical trunk* runs upwards to the summit of the pleura and then backwards above it, and sends its *superior intercostal branch* downwards behind it—between it and the neck of the first rib.

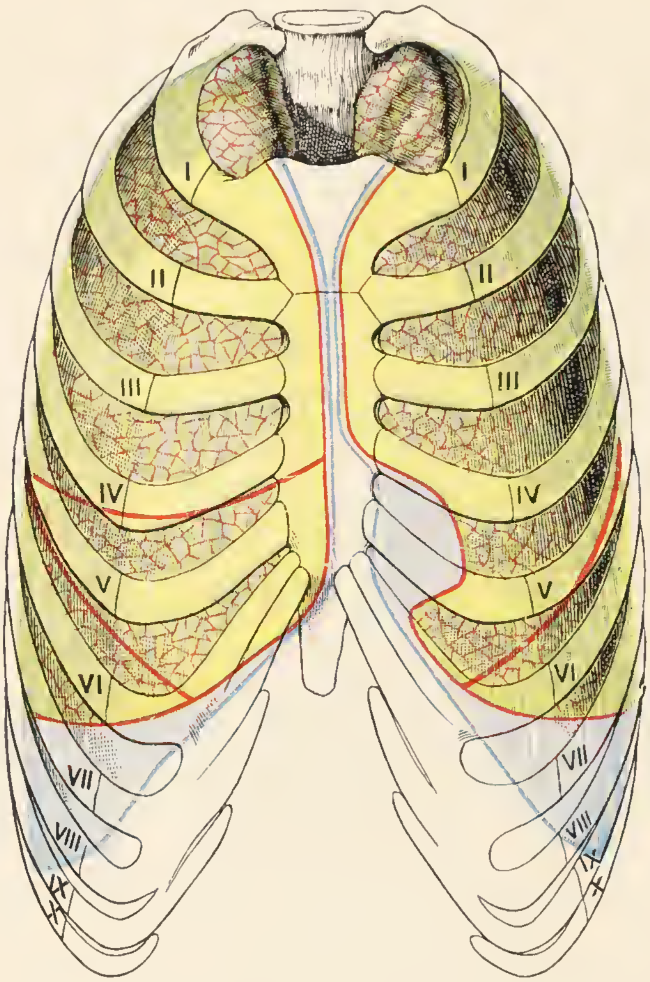


FIG. 11.—Diagram to show the Relation of Lungs and Pleuræ to anterior thoracic wall. Lungs are depicted in red, and pleuræ in blue.

Pleural Recesses.—Before the lung is removed, note that its anterior margin does not extend so far forwards and the inferior margin does not extend so far downwards as the corresponding parts of the pleura do. The portions of the pleural cavity unoccupied by the lung are called the **pleural recesses**. The recess along the anterior margin of the pleura is the *costo-mediastinal recess*, and that along the lower margin is the *costo-diaphragmatic*. The walls of the recesses are separated by a thin layer of pleural liquid ; and the margins of the lungs enter the recesses during inspiration and recede from them during expiration.

If the lungs have not been hardened *in situ*, the dissectors may, with the consent of the dissectors of the Head and Neck, introduce the nozzle of the bellows into the cervical part of the trachea and inflate the lungs with air. A truer conception of their size and form will then be obtained, and a demonstration will be afforded of their high elasticity, and of their connexion with the windpipe.

Dissection.—Pull the anterior margin of a lung laterally to expose its medial surface, its root and the pulmonary ligament ; then, divide the root and the pulmonary ligament, from above downwards, close to the medial surface of the lung. Remove the lung, wrap it in a cloth damped with preservative solution, and place it aside for future study. The other lung may be removed either in a similar manner, or after the constituents of its roots are separated (see *dissection instructions, pp.* 51 *and* 56).

Having removed the lungs, examine the margins of the

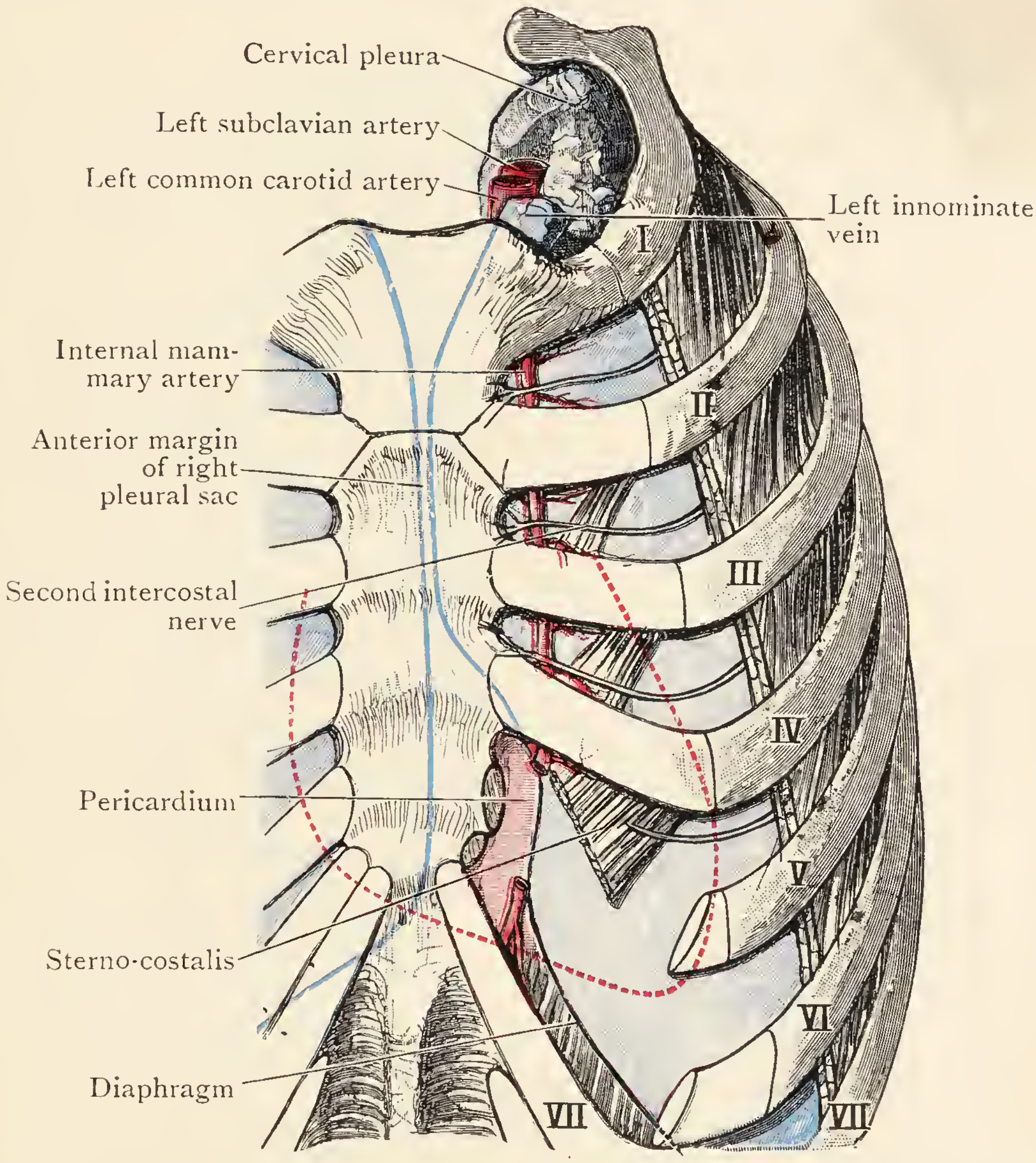


FIG. 12.—Diagram to show the Parts in front of Pericardium and Heart. The outline of the heart is indicated in red by a dotted line, and the anterior margins of the pleural sacs are represented by blue lines.

pleural sacs and note their position relative to the chest-wall (Figs. 11-14).

Lines of Pleural Reflexion.—Introduce one hand into the cavity of the pleura, and, placing an index finger in the **apex**, note that the summit is situated about one inch above the medial third of the clavicle ; if the whole clavicle has been removed, the dissector can still demonstrate this fact by placing a thumb in the position of that part of the clavicle. The apices of opposite sides are therefore some distance apart, and are separated from each other by the structures that occupy the median part of the neck: *i.e.* the trachea, the œsophagus, and the great vessels passing to and from the neck. As the **anterior margins** of the two pleuræ

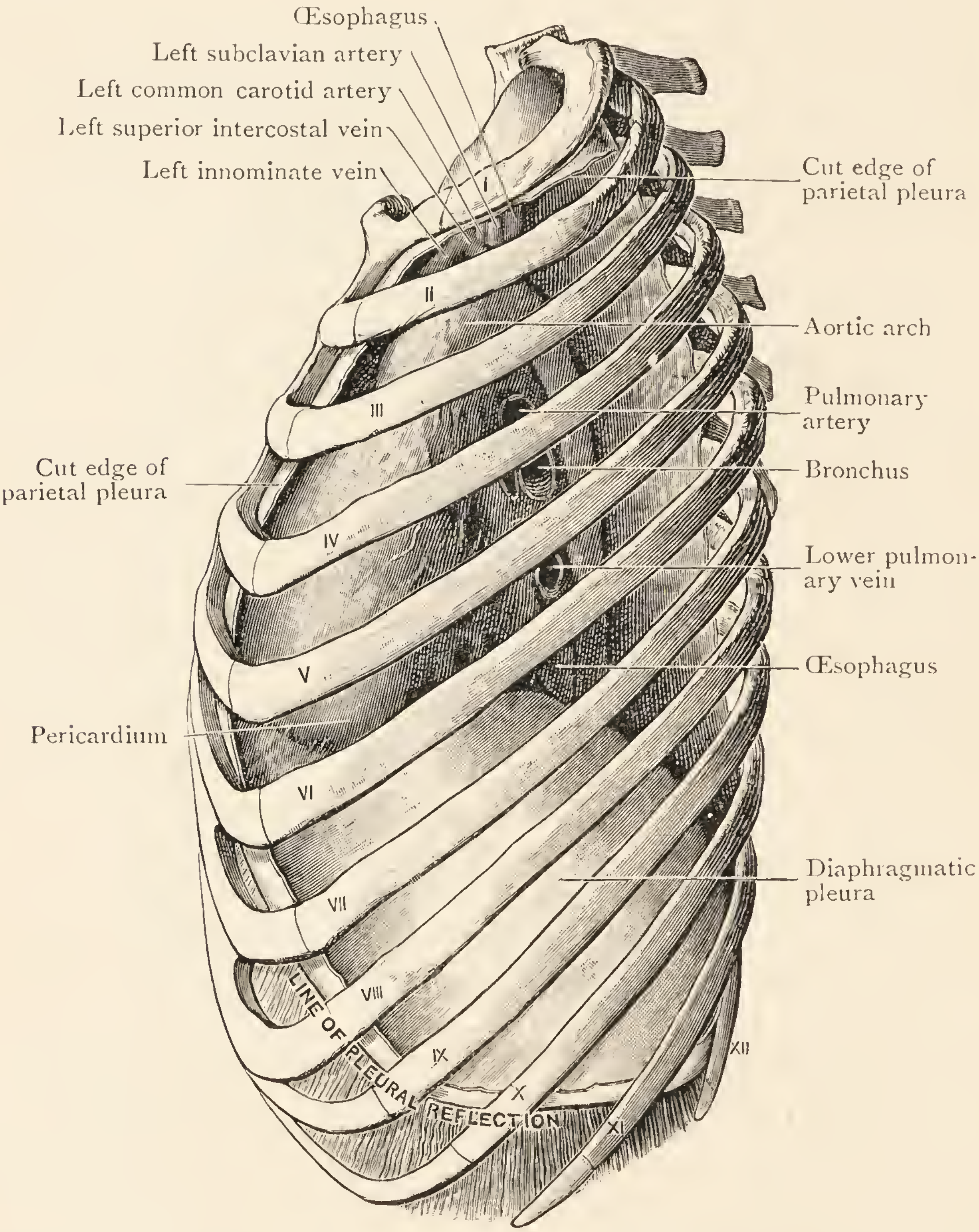


FIG. 13.—Left Pleural Sac of a subject hardened by formalin injection, opened into by the removal of the costal part of the parietal pleura.
The left mediastinal pleura has been exposed by the removal of the left lung. Note the line of pleural reflexion from the diaphragm.

are traced downwards from the apices they will be found to converge, for they pass behind the sterno-clavicular joints and come into apposition with each other at the lower border of the manubrium sterni immediately to the left of the median plane. Traced farther downwards, the anterior margins remain in apposition as far as the level of the fourth costal

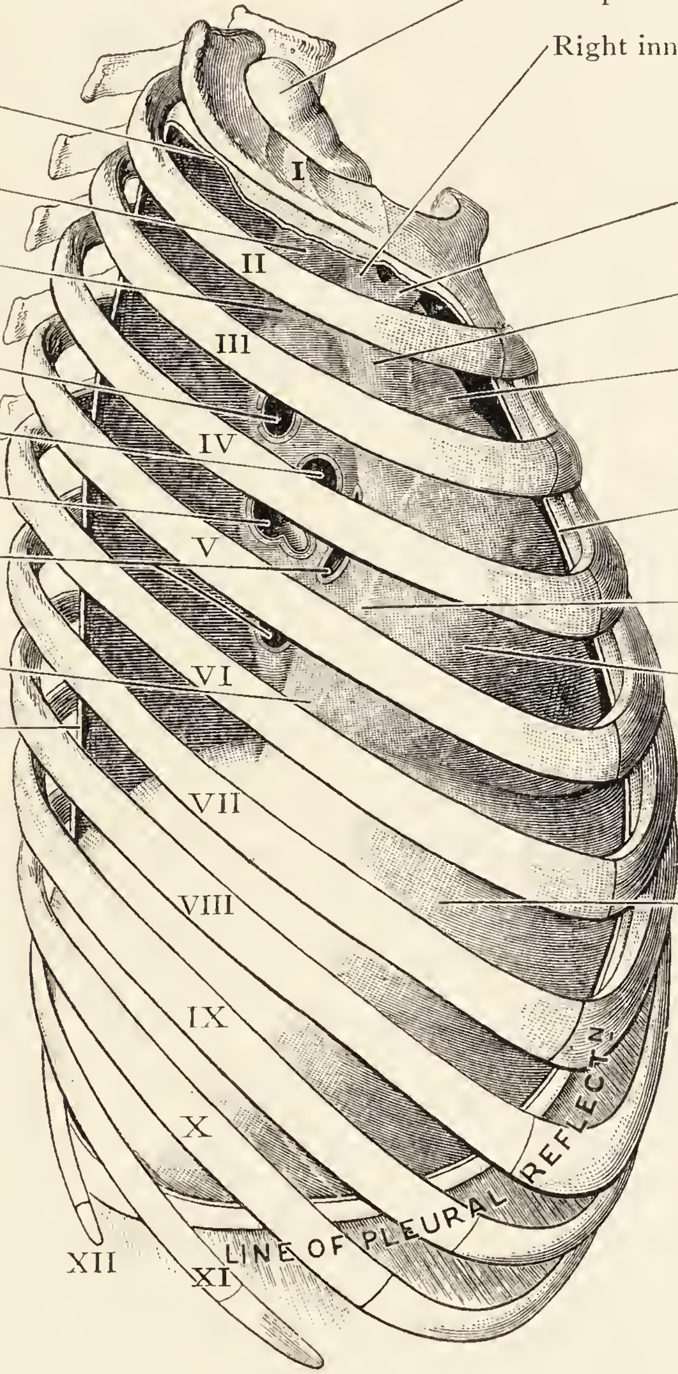


FIG. 14.—Right Pleural Sac of a subject hardened by formalin injection, opened into by the removal of the costal part of the parietal pleura. The right mediastinal pleura has been exposed by the removal of the right lung. Note the line of pleural reflexion from the diaphragm.

cartilages—the right often overlapping the left and both inclining slightly to the left.

From the fourth cartilage, the anterior margin of the *right* sac continues to descend, still with a slight inclination to the left, till it reaches the xiphi-sternal joint, where it becomes continuous with the inferior margin.

At the level of the fourth costal cartilage, the anterior margin of the *left* pleura turns away from the median plane and descends behind the fifth and sixth costal cartilages along the margin of the sternum or even as much as an inch to the left of the sternum, and reaches the level of the xiphi-sternal joint, where it becomes continuous with the lower margin of the pleura.

On each side, the **inferior margin** extends round the chest towards the twelfth thoracic spine. It passes behind the cartilage of the seventh rib, reaches the level of the tenth rib in the mid-axillary line, and then crosses the eleventh and twelfth ribs. Below the medial part of the twelfth rib, it meets the **posterior margin**, which ascends along the vetebral column to the apex.

The line for the lower border of the pleura, as it is drawn from the neighbourhood of the xiphi-sternal joint towards the twelfth thoracic spine, is convex downwards ; and it crosses the mid-axillary line about two inches above the costal margin. The lower margin of the lung follows a more horizontal course, and varies in level according to the phase of respiration. During expiration, it is opposite a line drawn from the xiphi-sternal joint towards the tenth thoracic spine, and it crosses the eighth rib in the mid-axillary line—about four inches above the costal margin. During inspiration, it extends downwards into the costo-diaphragmatic recess.

Keeping the above-mentioned points in mind, the student should mark out the margins of the pleural sacs on the living body, using himself and his friends for the purpose, until he can indicate them correctly, judging from the contour of the body alone and without feeling for the skeletal points.

Preliminary Explanation of Heart and Great Vessels.—Reference has to be made in the following pages to certain large vessels and certain parts of the heart before they can be fully dissected. If the Thorax is the first part allotted to the dissectors, they may not yet have had time to learn what these are; before they proceed farther, they should therefore read the following paragraphs and examine Figs. 25, 38, 50, 56 and 59.

The **heart** is a hollow, muscular organ divided into four chambers. These chambers are named the *right* and *left* *atrium* and *right* and *left ventricle*. The cavities of the two atria are separated from each other by a septum, and so are the cavities of the two ventricles; but each atrium communicates with the corresponding ventricle by means of a wide opening through which the blood can flow freely.

The atria form the upper and right parts of the heart and its posterior surface or base—only a small part of the left atrium being visible on the left side. The upper part of each atrium sends forwards a prolongation which is given the name *auricle* because of some resemblance to a dog's ear. The ventricles form the lower and left parts of the heart and its apex; and ventricles and atria are all seen on the front of the heart.

A great artery called the **aorta** springs from the uppermost part of the left ventricle. The aorta first *ascends* behind the breast-bone, and, secondly, *arches* backwards to the backbone, and then *descends* along the backbone into the abdomen; and the branches of the aorta carry blood to all parts of the body. That blood is brought back to the right atrium chiefly by two great veins called the **superior vena cava** and **inferior vena cava**; and from the right atrium it passes into the right ventricle.

The uppermost part of the right ventricle is called the *infundibulum* because it resembles a funnel. The upper end of the infundibulum is continuous with a wide vessel called the **pulmonary trunk.** This trunk, after a run of two inches backwards and upwards, divides into a pair of **pulmonary arteries**, which carry blood to the lungs; that blood is returned to the left atrium through two pairs of vessels called the **pulmonary veins** (an upper and a lower on each side); and from the left atrium the blood passes into the left ventricle.

Root of Lung in Section.—The dissectors will now examine the cut section of the root of the lung. As the right and left roots vary, each side must be considered separately, and the dissectors must make themselves acquainted with the conditions on both sides (Figs. 13-16; 22, 23).

On the right side, in the posterior part of the face of the section of the lung-root, at least two parts of the bronchial tube will be seen—an upper, called the *eparterial bronchus*, and a lower, much larger, called the *hyparterial bronchus*. In front of and between the two bronchi the *pulmonary artery* is seen, and farther forwards, and at a slightly lower level, the *upper pulmonary vein.* The *lower pulmonary vein* lies in the lowest part of the root. If the specimen is well injected, branches of the *bronchial artery* may be distinguished on the posterior faces of the air-tubes ; and anterior to and between the great blood-vessels, and between them and the bronchi, there is a number of bronchial *lymph-glands*, which are easily distinguished by the black pigment deposited within them.

On the left side, in the posterior part of the root of the lung, the dissectors will see the cut section of the *bronchus*. The *pulmonary artery* is above the bronchus, and its anterior wall is on a slightly anterior plane. The *upper pulmonary vein* is in front of the bronchus, and the *lower pulmonary vein* is below the bronchus. In a well-injected specimen, two *bronchial arteries* may be seen on the posterior wall of the bronchus, and a variable number of bronchial *lymph-glands* will be found between and around the large blood-vessels and the bronchus.

Structures seen through Pleura in Mediastinum and on Posterior Wall.—The dissectors will now endeavour to recognise the structures in the mediastinum through the mediastinal pleura on both sides.

On the right side (Figs. 14, 15 and 17), note a large bulging in front of and below the root of the lung : it is due to the *heart* within the *pericardium*. Continuous with the upper and lower ends of the posterior part of this bulging there are two longitudinal elevations. The upper, from the level of the third costal cartilage to the lower margin of the first rib, is due to the *superior vena cava*, and, above that level, to the *right innominate vein*. The lower elevation is very short and is caused by the upper part of the *inferior vena cava*. A secondary ridge, formed by the *phrenic nerve* and the accompanying blood-vessels, descends along the elevation caused by the innominate vein and the superior vena cava, crosses a little in front of the root of the lung, and runs down along the posterior part of the bulging due to the heart and the anterior border of the inferior caval elevation. Curving over the root of the lung there is a ridge made by the upper part of the *vena azygos* as it arches forwards to join the superior cava. Above the vena azygos and behind the superior vena cava, the right surface of the *trachea* may be seen or felt, and, descending obliquely across it from above downwards and backwards, the *right vagus nerve* can be palpated or seen. The

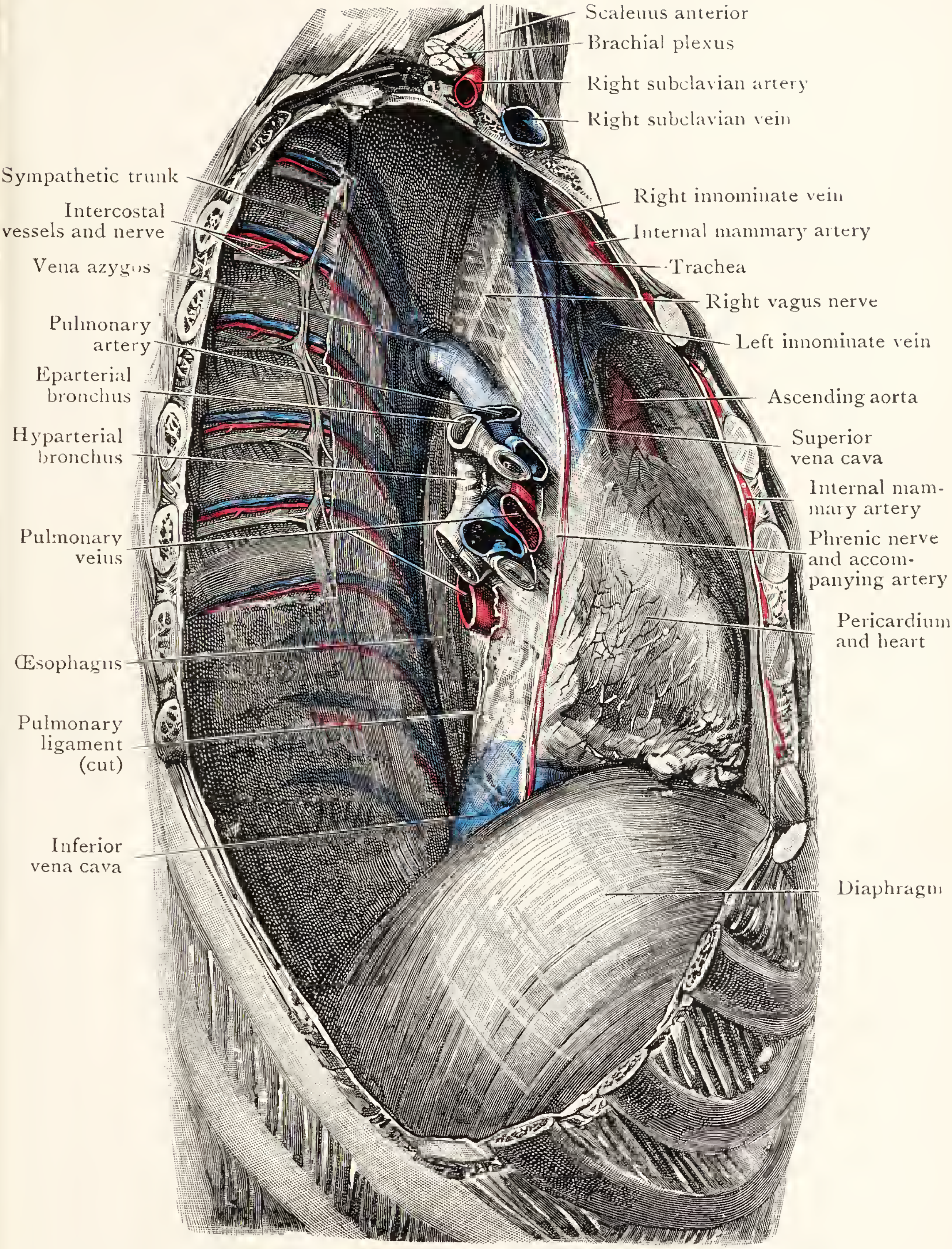


FIG. 15.—Right Pleural Chamber opened by removal of side wall of Thorax.

The Mediastinal Wall of the Pleural Chamber has been exposed by removal of the lung. Several of the structures in the Mediastinal Septum are seen shining through the Mediastinal Pleura, and a portion of the Costal Pleura has been removed. Compare with Fig. 17.

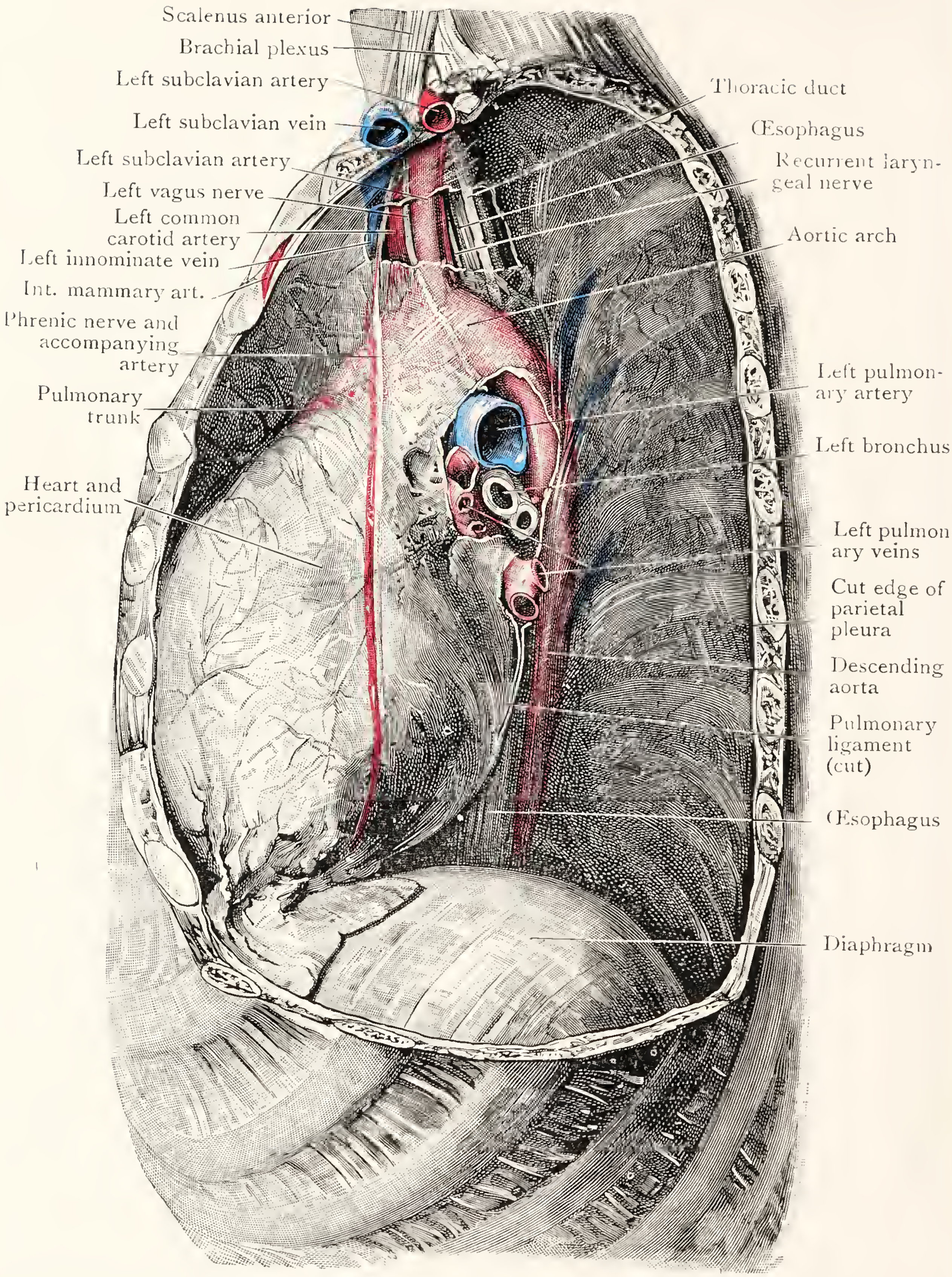


FIG. 16.—Left Pleural Chamber opened by removal of side wall of Thorax. The lung has been taken away and a "window" has been made into the Superior Mediastinum by the removal of a part of the Mediastinal Pleura. Several of the structures that form the Mediastinal Septum are seen shining through the remainder of the Mediastinal Pleura which is *in situ*. Compare with Fig. 18.

œsophagus may be seen or felt both behind the trachea and also, lower down, behind the root of the lung and the bulging due to the heart; in this lower part, the *vena azygos* may be seen ascending behind the œsophagus; and, still farther back, there are the bodies of the vertebræ and the posterior parts of the ribs. Crossing the bodies of the vertebræ, the *intercostal vessels* may be visible or they may be felt; the *sympathetic trunk* can be recognised by touch (if not by sight) as it descends across the heads of the upper ribs and over the sides of the lower vertebral bodies; and the roots of the *greater splanchnic nerve* may be seen passing downwards and forwards from the trunk.

On the left side (see Figs. 13, 16 and 18), the bulge of the *pericardium* and *heart* is seen below and in front of the root of the lung, and is larger than on the right side. The *arch of the aorta* curves to the left slightly and then backwards above the root of the lung; and from its posterior end the *descending aorta* runs downwards, first behind the root of the lung, and then behind the heart, but separated, in part, from the heart by the *œsophagus*, which inclines towards the left side in the lower part of the thorax. Above the arch of the aorta, the *left common carotid* and *subclavian arteries* and the *œsophagus* can be distinguished, in that order from before backwards. Note that the *thoracic duct* and the *left recurrent laryngeal nerve* also run upwards in this region—the duct on the left border of the œsophagus and the nerve immediately in front of the œsophagus. A long and slender secondary ridge, produced by the *phrenic nerve* and the accompanying vessels, descends along the line of the common carotid artery, crosses the arch of the aorta, and then continues along the side of the pericardium. Above the aortic arch, and behind the ridge caused by the phrenic nerve, the *vagus nerve* can be seen or felt as it runs downwards along the anterior border of the subclavian artery, and then downwards and backwards across the arch of the aorta to disappear behind the root of the lung. Lateral to the descending aorta and farther back, the *sympathetic trunk* can be seen or palpated as it descends first across the heads of the ribs and then on the sides of the bodies of the vertebræ, and the roots of the *greater splanchnic nerve* may be seen running obliquely downwards and forwards from it; and the intercostal vessels may be seen or felt as they cross the bodies of the vertebræ.

When the inspection and palpation of the structures that lie in relation with the mediastinal pleura and the posterior part of the costal pleura are satisfactorily completed, the greater part of the pleura should be removed on both sides.

Dissection.—Make a longitudinal incision through the mediastinal pleura immediately in front of the phrenic nerve, and a similar incision behind the nerve.

Carry an incision forwards from the anterior longitudinal incision at the level of the middle of the root of the lung, and another backwards from the posterior incision to the posterior wall of the thorax, encircling the root of the lung. When the incisions are completed, four flaps are marked out.

On each side, remove the posterior flaps completely—avoiding injury to the structures covered by them. Turn the lower anterior flap forwards as far as the anterior part of the pericardium ; cut it away there, but retain the pleura between the pericardium and the sternum.

On the right side, turn the upper anterior flap forwards as far as the superior vena cava ; cut it away there, but leave the pleura between the vena cava and the sternum.

On the left side, turn the upper anterior flap forwards to the anterior part of the pericardium and arch of the aorta, and cut it away ; but leave the pleura that extends from there to the sternum.

The next step is the cleaning of the structures exposed by the removal of the flaps of pleura.

Dissection.—*On each side*, clean the whole of the *sympathetic trunk*. Select two or three of its ganglia, and secure the two *rami communicantes* that connect each of them with the corresponding intercostal nerve. Clean all the branches that run downwards and forwards from the trunk to form the *splanchnic nerves*, and trace these nerves downwards as far as possible. Try to find some very slender branches that pass from the upper ganglia of the trunk to the pulmonary plexus on the back of the root of the lung and to the cardiac plexus on the end of the trachea.

Clean the *intercostal vessels* as they cross the bodies of the vertebræ and lie in the posterior part of the intercostal spaces ; and trace the *superior intercostal artery* and *first intercostal vein* up to the neck of the first rib.

Find the *vagus nerve*. The *right* nerve is on the right surface of the trachea ; the *left* nerve lies along the front of the left subclavian artery. Trace the nerve down to the back of the root of the lung, where it breaks up to form the posterior pulmonary plexus. Look for fine branches that pass from the nerve to the front of the root ; then, clean the *posterior pulmonary plexus*, and trace the continuation of the vagus from it to the œsophagus. As the pulmonary plexus is being cleaned, look for branches of the *bronchial artery* on the back of the bronchi.

Before the dissection is carried farther, note the following points :—

(1) The first posterior intercostal vein ascends into the neck to join the innominate vein.

(2) The upper two posterior intercostal arteries are branches of the superior intercostal artery, and they do not pass behind the sympathetic trunk (Fig. 9).

(3) All the other posterior intercostal veins and arteries pass behind the sympathetic trunk (Figs. 17 and 18).

(4) The second and third posterior intercostal veins (with a contribution from the fourth sometimes) unite to form the *superior intercostal vein* ; the *right* vein runs forwards and downwards to end in the vena azygos ; the *left* vein runs forwards and upwards over the left side of the arch of the aorta to end in the left innominate vein.

(5) All the other posterior intercostal veins of the *right* side end separately in the vena azygos. On the *left* side, the fourth to the eighth veins end in a common trunk called the *superior hemiazygos vein*, and the remaining veins join a common trunk called the *inferior hemiazygos vein* ; these two veins ultimately cross from left to right behind the descending aorta to end in the vena azygos behind the œsophagus.

The dissection should now be resumed.

Dissection.—*On the right side*, find the *vena azygos* above the root of the lung ; trace it backwards and then downwards as far as possible. Clean the right surface of the *trachea* and the right margin of the *œsophagus*, and follow the œsophagus as far down as the root of the lung. Finally, clean the *pericardium* and the two *venæ cavæ*, but leave the phrenic nerve and its covering of pleura undisturbed.

The dissectors of the right side will now pass to page 34 and study the parts that they have cleaned and then the parts cleaned by the dissectors of the left side (Figs. 17 and 18).

Dissection.—*On the left side*, return to the arch of the aorta and secure the *recurrent laryngeal branch* of the vagus, which arises there and curves medially below the arch. Clean the *superior intercostal vein* from its origin to the point where it crosses the phrenic nerve. Dissect carefully in the areolar tissue between the vagus and the phrenic nerves, and find two slender nerves—the *superior cervical cardiac branch of the left sympathetic trunk* and the *inferior cervical cardiac branch of the left vagus* ; trace them downwards to the lower border of the arch and upwards as far as possible.

Now, clean the *left subclavian artery* and the left side of the *œsophagus*—taking care not to injure the *left recurrent laryngeal nerve* ascending in front of the œsophagus, and the *thoracic duct* ascending along its left margin (Figs. 16 and 18). Then, clean the *pericardium*, but do not disturb the phrenic nerve and its covering of pleura ; and, lastly, clean the *descending aorta*.

The dissectors of the left side will now study the structures that they have cleaned and those cleaned by the dissectors of the right side (Figs. 18 and 17).

Contents of Mediastinum and the Structures of Posterior Wall of Thorax seen from the Right Side.—Below and in front of the root of the lung, there is the *pericardium*, covering the *right atrium* of the heart. The *inferior vena cava* is seen piercing the pericardium below and behind; and the *superior vena cava* pierces the upper part. The upper end of the superior vena cava is continuous with the *right innominate vein*, which lies behind the first costal cartilage. The terminal part of the *vena azygos* is seen arching over the root of the lung to join the superior vena cava. Above the azygos vein and behind the superior vena cava, there are parts of the *trachea*, *right vagus nerve* and *œsophagus* ; and the vagus can be followed to the back of the root of the lung, where it breaks up to form the *posterior pulmonary plexus*. The ascending part of the vena azygos is a little farther back, on the front of the bodies of the vertebræ. At a lower level, behind the pericardium, the right margin of the œsophagus will be found in front of the vena azygos.

Several structures are seen lateral to the vena azygos—the right *posterior intercostal arteries*, the accompanying *veins* and the *splanchnic nerves* and their roots. The *sympathetic trunk* is still farther from the median plane, and beyond it there are the *intercostal spaces* and their contents.

The *phrenic nerve*, still covered by the strip of pleura left *in situ*, descends along the right innominate vein, the superior vena cava, the pericardium and the inferior vena cava.

Contents of Mediastinum and the Structures of Posterior Wall of Thorax seen from the Left Side.—The *pericardium* is seen below and in front of the root of the lung and it conceals the *pulmonary trunk* and certain parts of the heart—*left atrium*, *left ventricle* and the *infundibulum* of right ventricle. The *arch of the aorta* is above the root of the lung, and it ends posteriorly in the *descending aorta*, which passes downwards behind the root of the lung and the pericardium ; but it is separated from the lower part of the pericardium by the *œsophagus*, which, at that level, is inclining towards the left side. The nerves on the left surface of the aortic arch, from behind forwards are the *left vagus*, the *superior cervical cardiac branch of the left sympathetic trunk*,

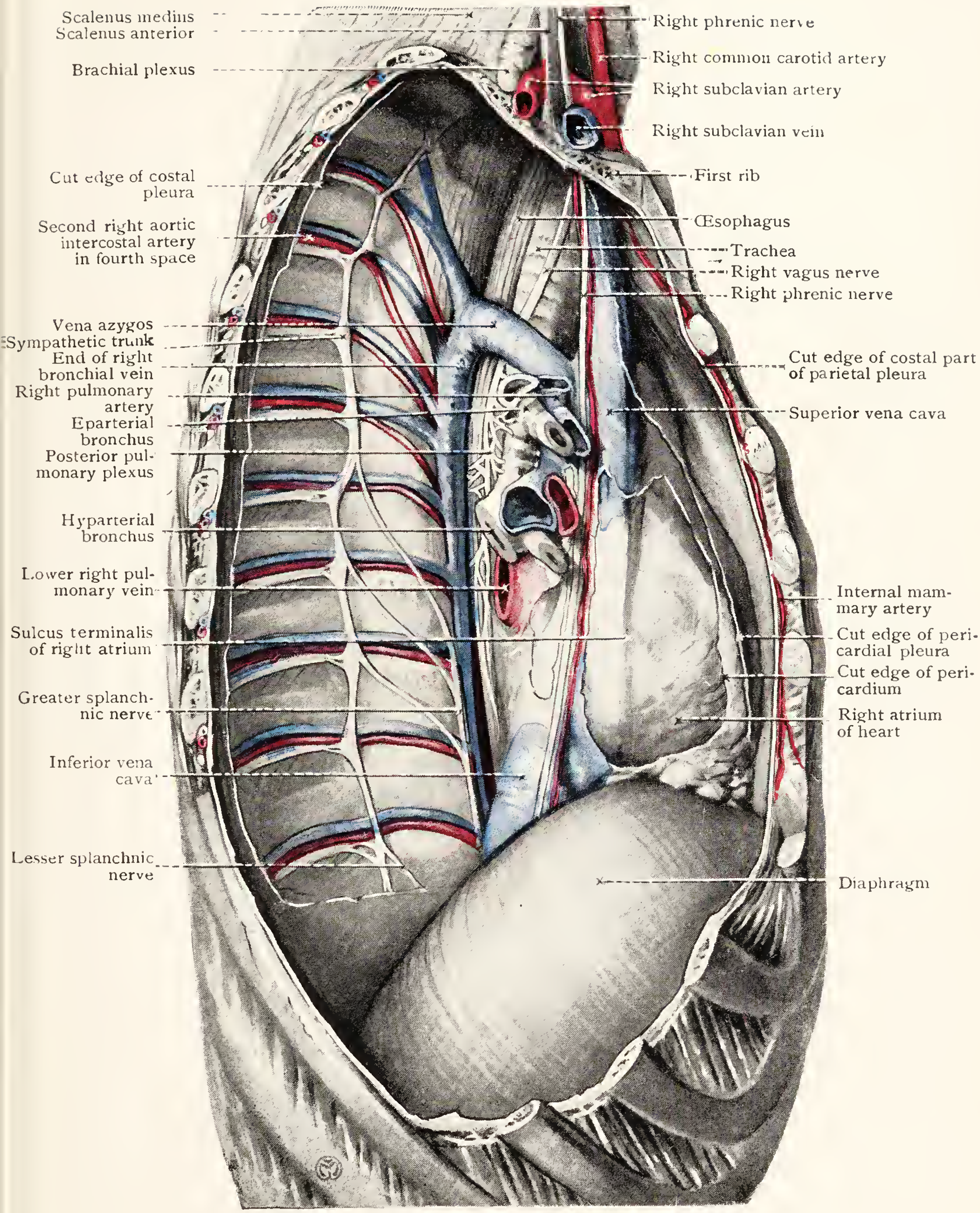


FIG. 17.—Right Side of Mediastinal Septum.

The Mediastinal and Costal parts of the Pleura have been removed, the Pericardium opened, and the structures exposed partly dissected. Compare with Fig. 15.

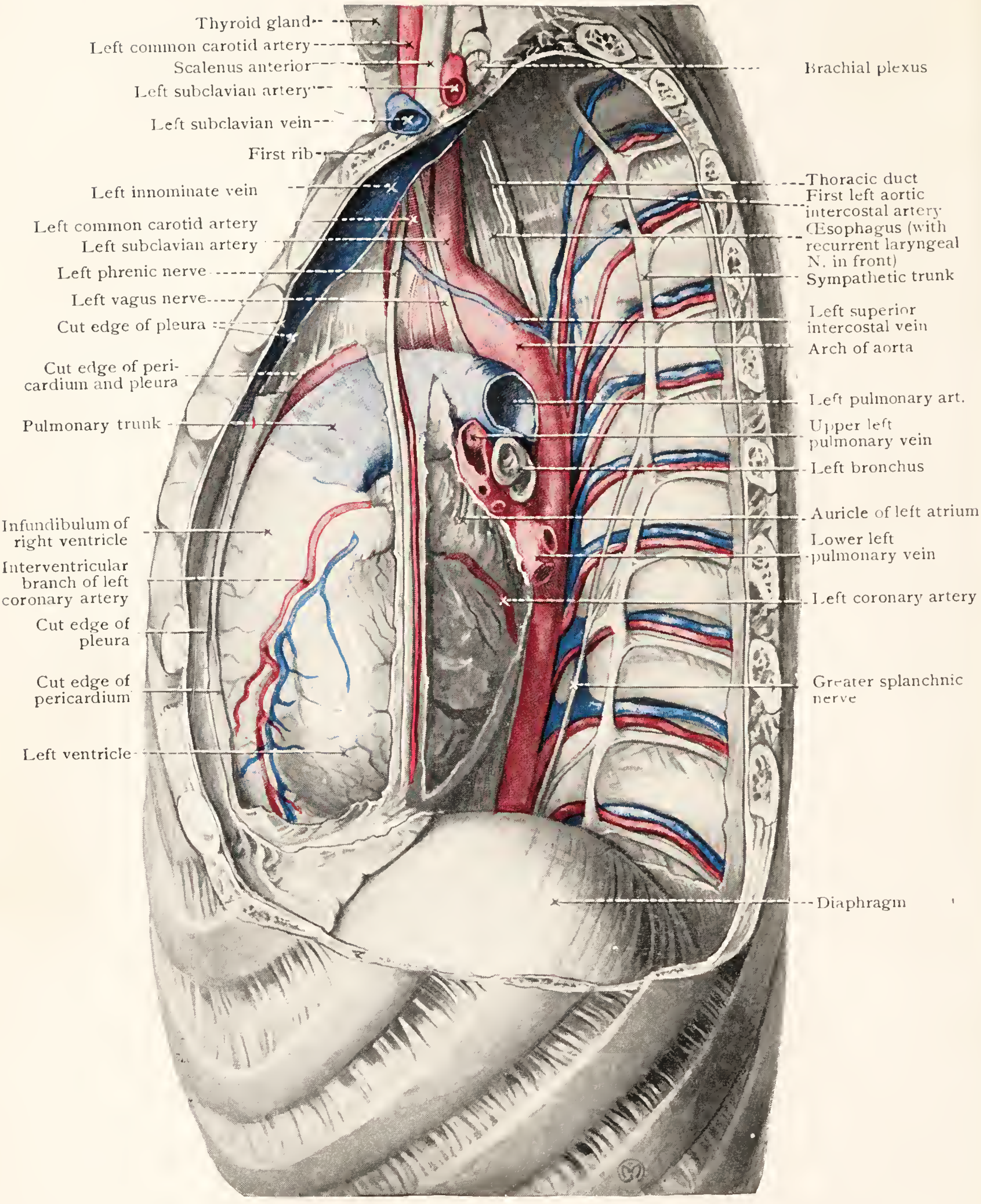


FIG. 18.—Left Side of Mediastinal Septum.

The Mediastinal and Costal parts of the Pleura have been removed, the Pericardium opened, and the structures exposed partly dissected. Compare with Fig. 16.

[*Facing p.* 35

the *inferior cervical cardiac branch of the left vagus*, and the left *phrenic nerve* with its accompanying vessels. The left *superior intercostal vein* crosses the arch obliquely, from behind forwards and upwards, passing lateral to the vagus and medial to the phrenic nerve. Above the arch of the aorta, two arteries are seen—the *left common carotid* and *left subclavian*; and, farther back, the *œsophagus* with the *thoracic duct* ascending along its left border, and the *left recurrent laryngeal nerve* ascending in front of it.

Identify the structures on the bodies of the vertebræ. They are:—the *hemiazygos veins* close to the descending aorta, the left *posterior intercostal arteries*, the accompanying *veins*, and the *splanchnic nerves* and their roots; and, still farther back and more laterally, the *sympathetic trunk* and the *intercostal spaces* and their contents.

After the relative positions of the structures exposed by the removal of the mediastinal pleura have been examined on both sides, the dissectors will study first the sympathetic trunk and its branches and communications, and then the subcostal muscles and the posterior intercostal membranes.

Sympathetic Trunk.—The sympathetic trunks are a symmetrical pair of long, slender nerve-cords, closely related to the bodies of the vertebræ. They form a very important part of the *sympathetic system* of nerves, which is itself a subdivision of the autonomic nervous system. A brief explanation of the sympathetic and autonomic systems is given on pp. 356 and 357 of this volume; and the dissectors should refer to these pages before they begin the study of the sympathetic trunk.

Each sympathetic trunk begins in the neck near the skull; it descends from the neck into the thorax, and from the thorax into the abdomen, and it ends in the pelvis on the front of the coccyx by uniting with the trunk of the other side. Throughout its course it is about one inch from the median plane.

In the upper part of the thorax, where vertebræ are narrow, the trunk lies on the necks and heads of the ribs, but, as the vertebræ widen, it comes to lie on the sides of their bodies; it crosses superficial to the aortic intercostal arteries and corresponding veins; and it is under cover of the pleura, through which it can be seen unless the pleura is thickened.

The trunk has the appearance of a knotted string. The knots are *ganglia*, which consist of nerve-cells and nerve-fibres. The parts between the ganglia consist of nerve-fibres alone. Typically, there are twelve ganglia on the trunk in the thorax —one for each vertebra—but the number may be reduced. The first ganglion is sometimes fused with the inferior cervical ganglion on the front of the neck of the first rib ; that is the normal condition in some animals, and, in them, this compound ganglion is named the " stellate ganglion " from its star-like shape.

Branches.—The thoracic branches are :—(1) rami communicantes ; (2) branches to the aorta, œsophagus, heart and lungs ; and (3) the splanchnic nerves.

The rami communicantes are two slender cords that connect each ganglion with the corresponding intercostal nerve. The *grey ramus communicans* passes backwards from the ganglion to the nerve, and consists of non-medullated fibres that arise in the cells of the ganglion. The *white ramus communicans* lies alongside the grey ramus. It consists of medullated fibres which arise in the spinal cord and pass to the sympathetic trunk from the intercostal nerve.

The *aortic* and *œsophageal nerves* are slender filaments that pass to the thoracic aorta and to the œsophagus from the upper five ganglia (and, in the lower part of the thorax, from the greater splanchnic nerve also).

The *cardiac* and *pulmonary nerves* spring from the second, third and fourth ganglia. They run downwards and forwards on the vertebral bodies to the side of the œsophagus, and thence to the cardiac plexus and the posterior pulmonary plexus.

The splanchnic branches arise from the fifth to the last ganglion, and they unite to form three distinct nerves—the greater, the lesser and the lowest splanchnic nerves, which are all destined for the abdominal viscera.

The *greater splanchnic nerve* is formed by the union of long, slender roots that arise from the fifth to the ninth ganglia and pass obliquely downwards and forwards over the vertebral bodies, superficial to the intercostal vessels, towards the azygos vein or the inferior hemiazygos vein. The nerve descends over the vertebral column, immediately lateral to the vein ; it enters the abdomen by piercing the crus of the diaphragm, and it ends in a large ganglion called the cœliac ganglion.

Opposite the last thoracic vertebra there is frequently a small ganglion on the greater splanchnic nerve; from that ganglion, as well as from the nerve, branches are distributed to the aorta and the œsophagus. The œsophageal branches join the *œsophageal plexus*, and some of them are continued to the stomach (pp. 118, 285).

The *lesser splanchnic nerve* arises by two roots from the tenth and eleventh ganglia. It also pierces the crus of the diaphragm and ends in the cœliac ganglion.

The *lowest splanchnic nerve* is a minute branch which springs from the last thoracic ganglion. It is frequently absent, but when it is present it pierces the crus of the diaphragm and ends in the plexus of sympathetic nerves around the renal artery.

Subcostal Muscles.—Clean the intercostal spaces as far as the angles of the ribs, where the internal intercostal muscles end. Thin muscular slips that run in the same direction as the internal intercostal muscles will generally be found descending from one rib to the second or third below. Such slips constitute the *subcostal muscles*, which form a part of the transversus thoracis muscle (p. 15). They are very variably developed; sometimes they form an almost complete lining for the posterior part of the thoracic wall; but they may be represented only by a few scattered slips, and occasionally they are entirely absent.

Posterior Intercostal Membranes.—These membranes are medial to the internal intercostal muscles and on a more posterior plane. Each is attached, medially, to the superior costo-transverse ligament, which passes from the neck of a rib to the transverse process of the vertebra above. Laterally, the membrane is continuous with the fascial layer between the internal and external intercostal muscles; and, above and below, it is attached to the adjacent ribs. The intercostal nerve and vessels run laterally on the pleural surface of the membrane (Figs. 17 and 18), and disappear behind the border of the internal intercostal muscle. When the membranes are removed, the posterior fibres of the external intercostal muscles will be exposed, for they extend medially as far as the tubercles of the ribs.

The dissectors will now complete the cleaning of the vena azygos and will study it and the left superior intercostal vein.

Vena Azygos.—The azygos vein arises in the abdomen from the back of the inferior vena cava, and enters the thorax through the aortic opening of the diaphragm (p. 4), to the right of the aorta and thoracic duct, the lower parts of which were displayed as the vein was cleaned. After the vein enters the thorax, it ascends behind the diaphragm along the right side of the aorta, from which it is separated by the thoracic duct. It then escapes from behind the diaphragm, and ascends behind the right border of the œsophagus. At the lower part of the fourth thoracic vertebra it emerges from behind the œsophagus, and arches forwards over the root of the lung to join the back of the superior vena cava. As it arches forwards it crosses the right side of the œsophagus, trachea and vagus nerve (Figs. 17, 19), and is so closely related to the right pleura and lung that it grooves the lung above the hilum. Its entrance into the vena cava is immediately above the pericardium, opposite the second costal cartilage. Since it arises from one vena cava and ends in the other, it forms an important anastomosis between the two.

Tributaries.—The veins that enter the vena azygos are :—(1) The right superior intercostal vein, which drains blood from the greater part of the second and third intercostal spaces. (2) The lower eight posterior intercostal veins and the subcostal vein of the right side. (3) The inferior hemiazygos vein, and frequently (4) the superior hemiazygos vein. (The superior hemiazygos vein sometimes joins the inferior.) (5) Two or more bronchial veins from the right lung. (6) Some veins from the œsophagus. (7) Some minute pericardial veins.

Left Superior Intercostal Vein.—This vein is formed by the union of the posterior intercostal veins from the second and third intercostal spaces of the left side, and it not uncommonly receives communicating veins from the first and fourth spaces. It descends along the medial border of the third left posterior intercostal artery to the posterior end of the aortic arch ; it then turns forwards along the left side of the aortic arch, and, passing at the same time obliquely upwards, it crosses lateral to the left vagus and medial to the left phrenic nerve (Fig. 18). In a later dissection it will be traced to its termination in the left innominate vein.

The posterior intercostal veins and the accompanying arteries and nerves and the hemiazygos veins will be studied after the descending aorta has been examined (see p. 126).

The dissectors will now dissect the phrenic nerve.

Dissection.—On both sides remove the strip of pleura left over the *phrenic nerve* ; then, clean the nerve and the accompanying vessels, but do not displace the nerve. If the nerve is accidentally displaced, re-fix it by a few stitches.

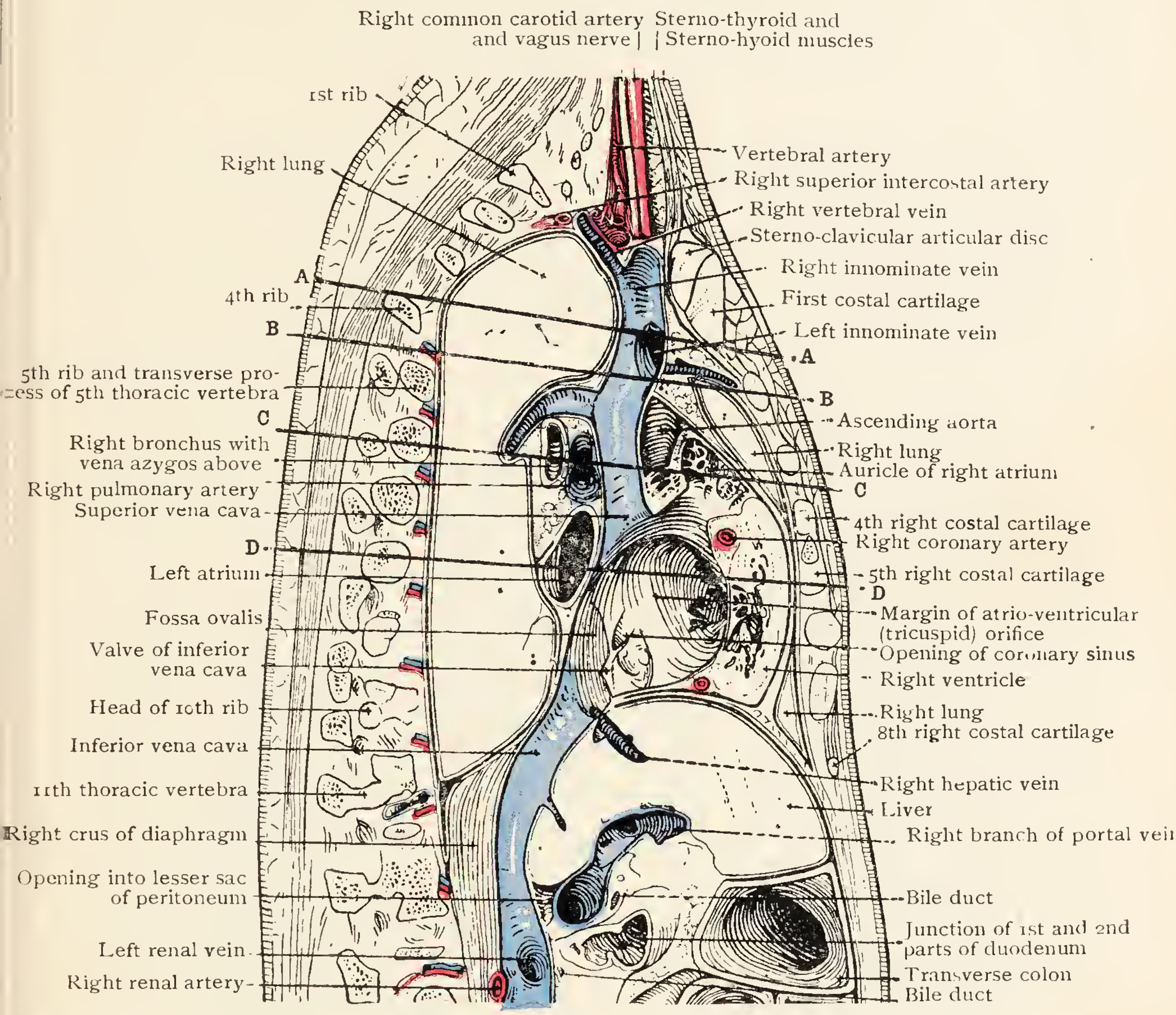


FIG. 19.—Sagittal Section (partly dissected) of upper part of Trunk of a young man. The section is along the line of the superior and inferior venæ cavæ, and it passes through the right extremity of the cavity of the left atrium. Cf. Fig. 35. The atria were partially distended and the ventricles were contracted. Note that in this specimen the heart was lower than usual, in relation to costal cartilages.

A-A. Plane of section of Fig. 27.
B-B. ,, ,, ,, 28.
C-C. Plane of section of Figs. 26 and 50.
D-D. ,, ,, ,, 25 ,, 55.

Phrenic Nerves.—This pair of nerves is of very great importance because they are the nerves of supply to the diaphragm—the chief muscle of respiration. Each of them arises in the neck, where it takes origin from the fourth cervical nerve and receives additional fibres from the third and the fifth. It descends over the scalenus anterior muscle and, on the right side, at the root of the neck, it crosses in front of the subclavian artery and descends obliquely behind the innominate vein, crossing the internal mammary artery from its lateral to its medial side. On the left side, after it leaves the scalenus anterior, it descends parallel with and in front of the subclavian artery and passes behind the commencement of the innominate vein.

It enters the thorax opposite the first costal cartilage, and then descends along the side of the mediastinum to reach the diaphragm, where it breaks up into branches. The majority of the branches pass through the fleshy part of the diaphragm and are distributed to the muscle from its lower surface—after communicating with the sympathetic nerve-fibres that accompany the phrenic branch of the abdominal aorta.

Relations of Phrenic Nerve in Thorax.—In its descent through the thorax, each phrenic nerve is accompanied by the pericardiaco-phrenic vessels ; it is closely related laterally to the pleura and lung, and it is a little in front of the root of the lung. Otherwise the relations are different on the two sides.

The **right phrenic nerve** descends along the right side of the right innominate vein and the superior vena cava till the vena cava enters the pericardium ; it then runs along the side of the pericardium, which separates it from the right atrium (Figs. 17, 25-28), and, finally, along the upper part of the inferior vena cava as far as the diaphragm.

In the upper part of the thorax, the **left phrenic nerve** runs downwards between the left common carotid and the left subclavian arteries and, while it lies between them, it crosses in front of the left vagus. In the next stage of its descent, it passes lateral to the arch of the aorta and the left superior intercostal vein ; it then leaves the aorta and runs downwards along the side of the pericardium, which separates it from the auricle of the left atrium and from the left ventricle of the heart (Figs. 18, 25-28).

Branches of Phrenic Nerve.—The main distribution of the phrenic nerve is to the diaphragm, but some minute sensory twigs are given off by each nerve to the pericardium and to the parietal pleura. Abdominal branches also are described ; they pass to the inferior vena cava, the suprarenal glands, and the liver, through the communications with the plexus of sympathetic nerves around the phrenic branch of the abdominal aorta.

Pericardiaco-Phrenic Artery.—This is a long and very slender artery that arises from the internal mammary artery at the root of the neck. It accompanies the phrenic nerve to the diaphragm, but gives twigs also to the pleura and the pericardium. Its *venæ comitantes* end in the internal mammary vein.

The dissectors will now proceed to study the lungs. If the lungs were hardened *in situ* and are fairly healthy, they will serve the purpose best, especially when the relations of the medial surface are examined; but, if they are collapsed or excavated by disease, their place may be taken by casts.

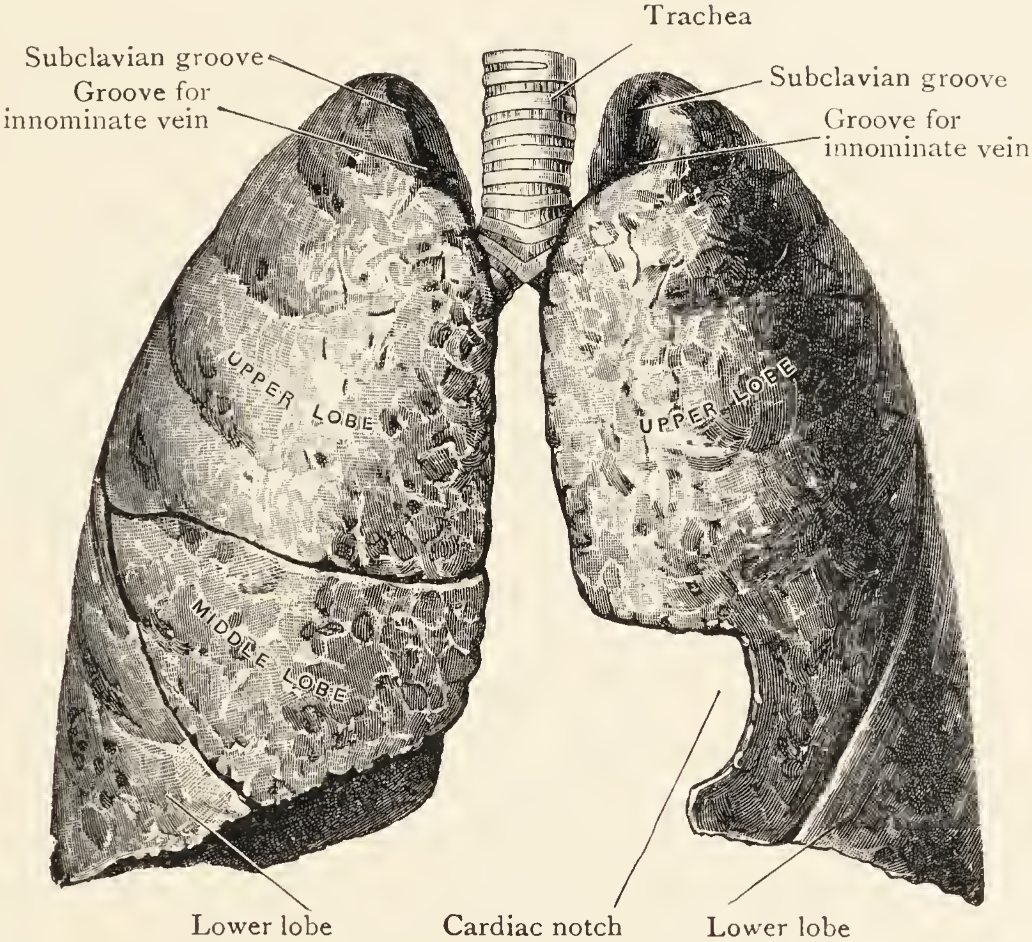


FIG. 20.—Trachea, Bronchi, and Lungs of a child, hardened *in situ*.

Pulmones.—The **lungs** are a pair of comparatively light organs, soft to the touch and spongy in texture, and if a small portion is pressed between the fingers and thumb a peculiar sound called *crepitation* is heard as the air is forced from one part to another. The ground colour of the surface of the adult lung of town-dwellers is slate-blue, but it is mottled with patches and fine lines of black caused by deposited carbon particles. The lungs of children are of a yellowish-pink colour, similar to the colour of the lungs of healthy sheep.

The elasticity of the healthy lung-substance is remarkable, but the student will not be able to demonstrate it in a lung hardened by preservatives or injured by disease. He can, however, obtain the fresh lungs of a sheep from a butcher, and then, by inflating them through the trachea with the aid of a bellows, he will have no difficulty in satisfying himself of their elasticity. The dissectors noted, when they opened the pleural sac (see p. 19), either that the lung shrank to one-third its previous bulk, or that its shape and size remained unchanged. If it remained unchanged it either was diseased, or had been hardened *in situ*. If it shrank, it was healthy and unfixed by reagents, and its elasticity was demonstrated.

The weight of an adult healthy right lung, containing an average amount of blood, is about 620 grm. (22 oz.), and that of the left is 570 grm. (20 oz.). But it is so light in comparison with its bulk that the whole lung, or any healthy portion of it, will float in water, though portions that are consolidated by disease will sink.

The lung of an infant which has not breathed will not float in water. Before the first respiration (which takes place after birth) the lungs are solid organs, and their bulk is small in proportion to their weight; therefore, when they are removed from the body and placed in water, they sink—a fact which is made use of as a medico-legal test of "live birth."

The lungs, when healthy, lie free in the cavity of the chest, and are attached only by their roots and pulmonary ligaments. A healthy lung, however, is seldom seen in the dissecting-room, and adhesions due to pleurisy are usually present between the pulmonary and parietal layers of the pleura.

Each lung is accurately adapted to the space in which it lies, and, when hardened *in situ*, it bears, on its surface, impressions and elevations which are an exact counterpart of the inequalities of the structures with which its surfaces were in contact at the moment of fixation.

Each lung resembles half a cone; and it presents for examination an *apex*, a *base*, a *costal surface*, and a *medial surface*. *Anterior* and *posterior borders* separate the medial from the costal surface; and an *inferior border* separates the basal surface from the other surfaces.

Apex and Base of Lung.—The *apex* rises into the root of the neck for an inch and a half above the level of the anterior part of the first rib. It lies behind and above the medial third of the clavicle and is crossed by the subclavian artery, which makes a groove on the anterior border a short distance below the summit, although the lung is separated from the artery by the pleura and a thin membrane called the *supra-pleural membrane.*

The *base* of each lung has a semilunar outline and is adapted to the upper surface of the diaphragm. Consequently, it is deeply hollowed out, and, as the right cupola of the diaphragm is higher than the left, the basal concavity is deeper in the right lung than in the left lung.

The diaphragm separates the base of the right lung from

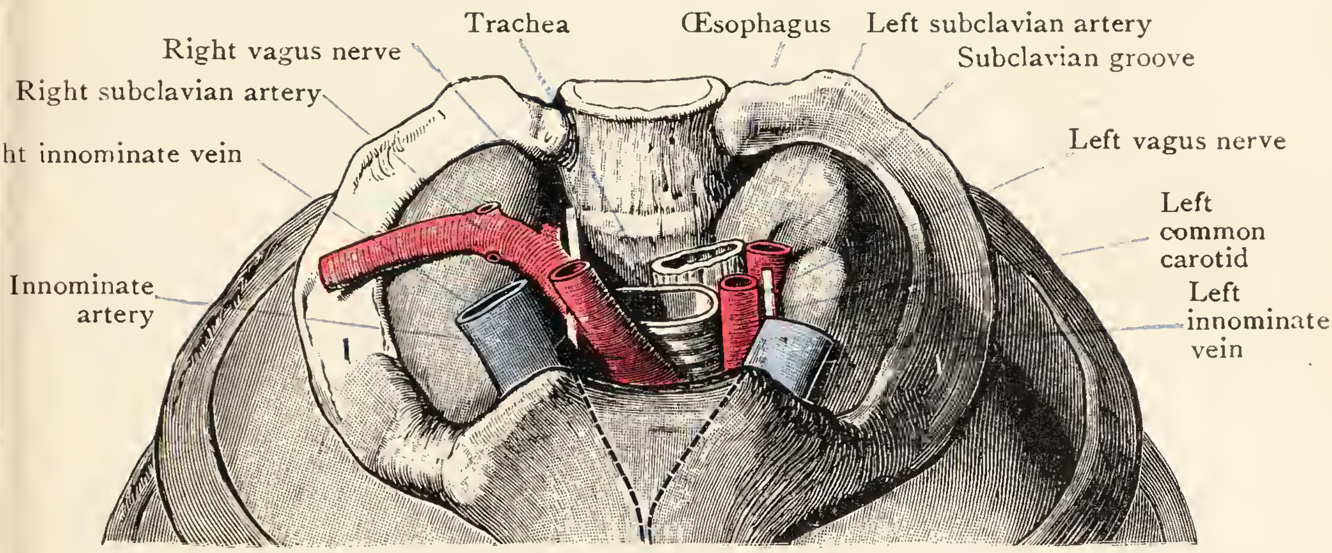


FIG. 21.—Cervical Pleuræ and Apices of Lungs.

the right lobe of the liver, and the base of the left lung from the left lobe of the liver, the stomach and the spleen.

Borders and Surfaces of Lung.—The mediastinal part of the *inferior border* is related to the lower border of the pericardium, and is often blunt ; but the anterior, lateral and posterior parts are thin and sharp and extend downwards into the costo-diaphragmatic recess of the pleura. The lateral and posterior parts are lower than the anterior part, but all the parts fall short of the bottom of the recess, except in forced inspiration.

The anterior and posterior borders of the lung are in marked contrast with each other The *anterior border* is comparatively short and thin, and extends medially into the costo-mediastinal recess of the pleura. It begins at the apex, curves downwards, forwards and medially, behind the sterno-clavicular joint, to the lower border of the manubrium sterni, and then it descends to the base of the lung at the level of the xiphi-sternal joint. A little below the summit, it is grooved by the subclavian artery; and, in the left lung, it presents a *cardiac notch* at the level of the fifth costal cartilage. The *posterior border* is the indistinct confluence of medial and costal surfaces on the rounded, thick part of the lung that occupies the deep hollow of the thoracic cavity at the side of the vertebral column.

The *costal surface* of the lung is convex and very extensive. It lies in relation with the costal pleura, which separates it from the ribs and intercostal muscles and from the sterno-costalis and sternum.

The *medial surface* is separable into an anterior or *mediastinal part* and a posterior or *vertebral part*.

The vertebral part lies against the sides of the bodies of the vertebræ (Figs. 25, 26, 27, 31), and is related therefore to intercostal vessels, the sympathetic trunk and the roots of the greater splanchnnic nerve (Figs. 17 and 18).

The mediastinal part is applied to the mediastinal partition and presents markings which are the exact counterparts of the inequalities of the surface of the mediastinum.

Hilum of Lung.—The hilum, situated far back in the mediastinal area, is abóut the centre of the medial surface. It is a large, wedge-shaped, depressed area through which the bronchus and the pulmonary artery, nerves, veins and lymph-vessels enter or leave the lung. It is surrounded by the pleura which is reflected from its margins on to the root of the lung; and the layer of reflected pleura around the hilum is continuous, below, with the pulmonary ligament (Figs. 22, 23).

Relations of Mediastinal Area of Lung.—Examine the relations of the mediastinal area of the two lungs separately, for they differ on the two sides. As each related structure is mentioned, find it again in the mediastinum, and, if the lung has been hardened *in situ*, fit it into place from time to time and confirm the statement of relationship. If the lung is misshapen by disease or is collapsed, this procedure will not be of help, and the student will then compare Fig. 22 with Fig. 17, and Fig. 23 with Fig. 18. Study also Figs. 25, 26, 27 and 31.

In the **right lung** there is a wide, concave area that extends from the hilum and pulmonary ligament to the anterior margin of the lung, and is related to the *pericardium*. At the lowest part of this area, immediately in front of the pulmonary ligament, there is a depression made by the uppermost part of the *inferior vena cava.* The *superior vena cava* makes a wide, shallow vertical groove partly in the pericardial area immediately in front of the upper half of the hilum and partly above the pericardium ; and this groove is continuous superiorly

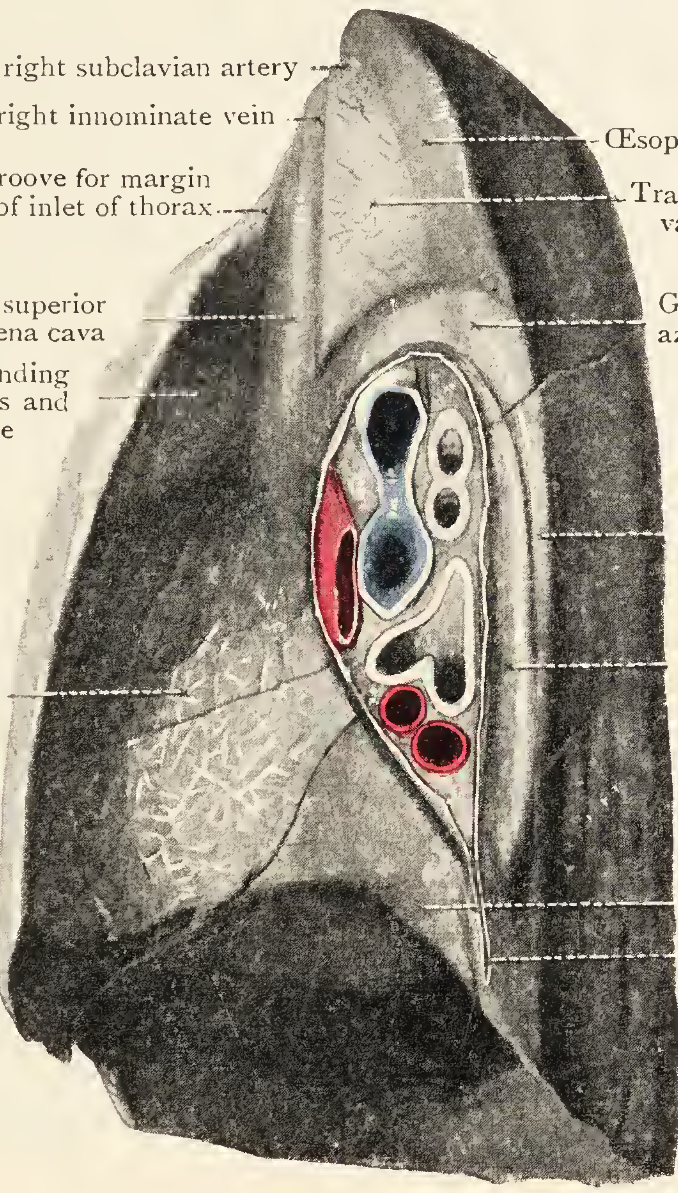


FIG. 22.—Medial Surface of a Right Lung hardened *in situ.*

with a narrower groove made by the *right innominate vein.* In front of the groove for the superior vena cava, there is an area related to the *ascending aorta* as it passes obliquely upwards from the heart to become continuous with the arch ; and this area is related also to the fatty tissue around the remains of a degenerated gland called the *thymus* (p. 60).

The vertical strip behind the hilum—about a finger's breadth—is related to the *œsophagus* and also to the *vena azygos* if that vein comes into view behind the œsophagus

(Fig. 26). As the vena azygos arches forwards above the root of the lung, it makes a narrow, clean-cut horizontal groove above the hilum, and this groove joins that for the superior vena cava at a right angle.

The area above the groove for the vena azygos and behind the groove for the superior vena cava is related to the right

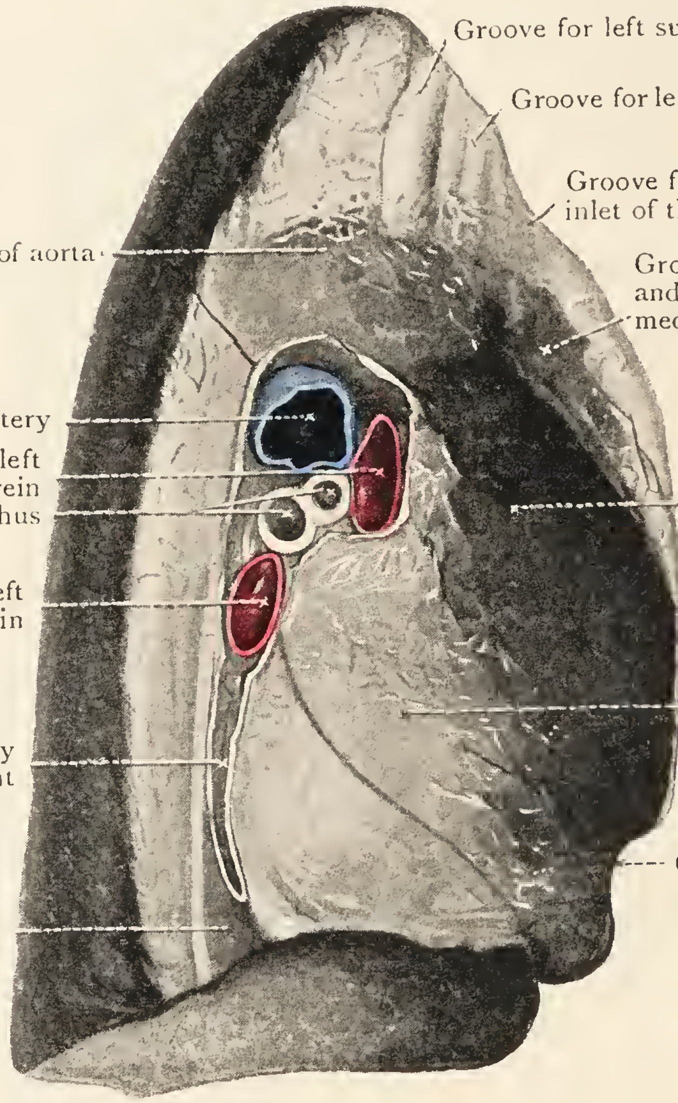


FIG. 23.—Medial Surface of a Left Lung hardened *in situ*.

side of the *trachea*, to the *right vagus nerve* on the side of the trachea and to the *œsophagus* behind the trachea.

The *right phrenic nerve* and its accompanying vessels may make a very narrow groove as they descend along the right side of the right innominate vein, superior vena cava, pericardium and inferior vena cava (Fig. 17).

In the **left lung** also there is a wide concavity for the *pericardium* in front of the hilum and pulmonary ligament; it is deeper than in the right lung, for the heart and pericardium

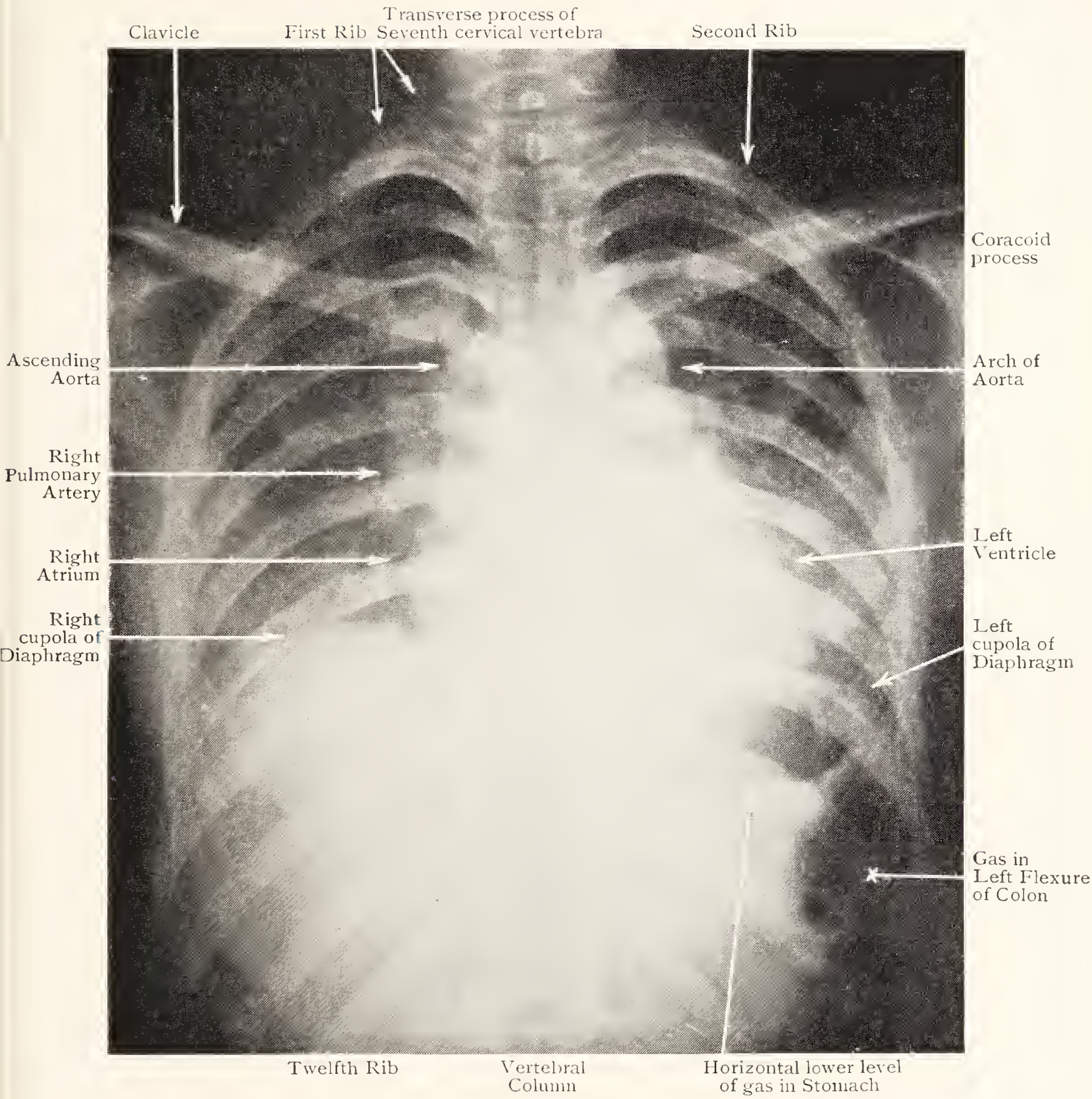


FIG. 24.—Radiograph of the same Thorax (youth aged 18) as in Figs. 7 and 8 in position of Full Expiration.

Note the descent of the medial parts of the Clavicles, the rise of the Diaphragm, the broadening of the Heart and Great Vessels, the greater obliquity of the Ribs, and the greater density of the Lungs.

FIG. 25.—Transverse Section of Thorax of a young man along line **D-D**, Fig. 19. Seen from below. The section passes through the intervertebral disc between the seventh and eighth thoracic vertebrae. An outline of the next section seen from above is given in Fig. 55.

1. Eighth rib.
2. Right pleural cavity.
3. Right lung.
4. Azygos vein.
5. Thoracic duct.
6. Œsophagus.
7. Right bronchus.
8. Right pulmonary vein.
9. Left atrium.
10. Fossa ovalis.
11. Superior vena cava.
12. Atrial septum.
13. Medial cusp of tricuspid valve.
14. Anterior cusp of tricuspid valve.
15. Right coronary artery.
16. Right ventricle.
17. Fifth costal cartilage.
18. Sternum.
19. Ventricular septum.
20. Internal mammary vessels.
21. Pectoralis major.
22. Left ventricle.
23. Pericardium.
24. Mitral valve.
25. Cut edge of atrial septum.
26. Coronary sinus.
27. Left pulmonary vein.
28. Left bronchus.
29. Left lung.
30. Descending aorta.
31. Superior hemiazygos vein.

[*Facing p.* 47

bulge more to the left than to the right. The vertical strip behind the hilum and pulmonary ligament is related to the *descending aorta*; and, close to the base of the lung, there is a narrow, triangular area related to the part of the *œsophagus* that lies in front of the descending aorta.

As the *arch of the aorta* curves backwards above the peri-

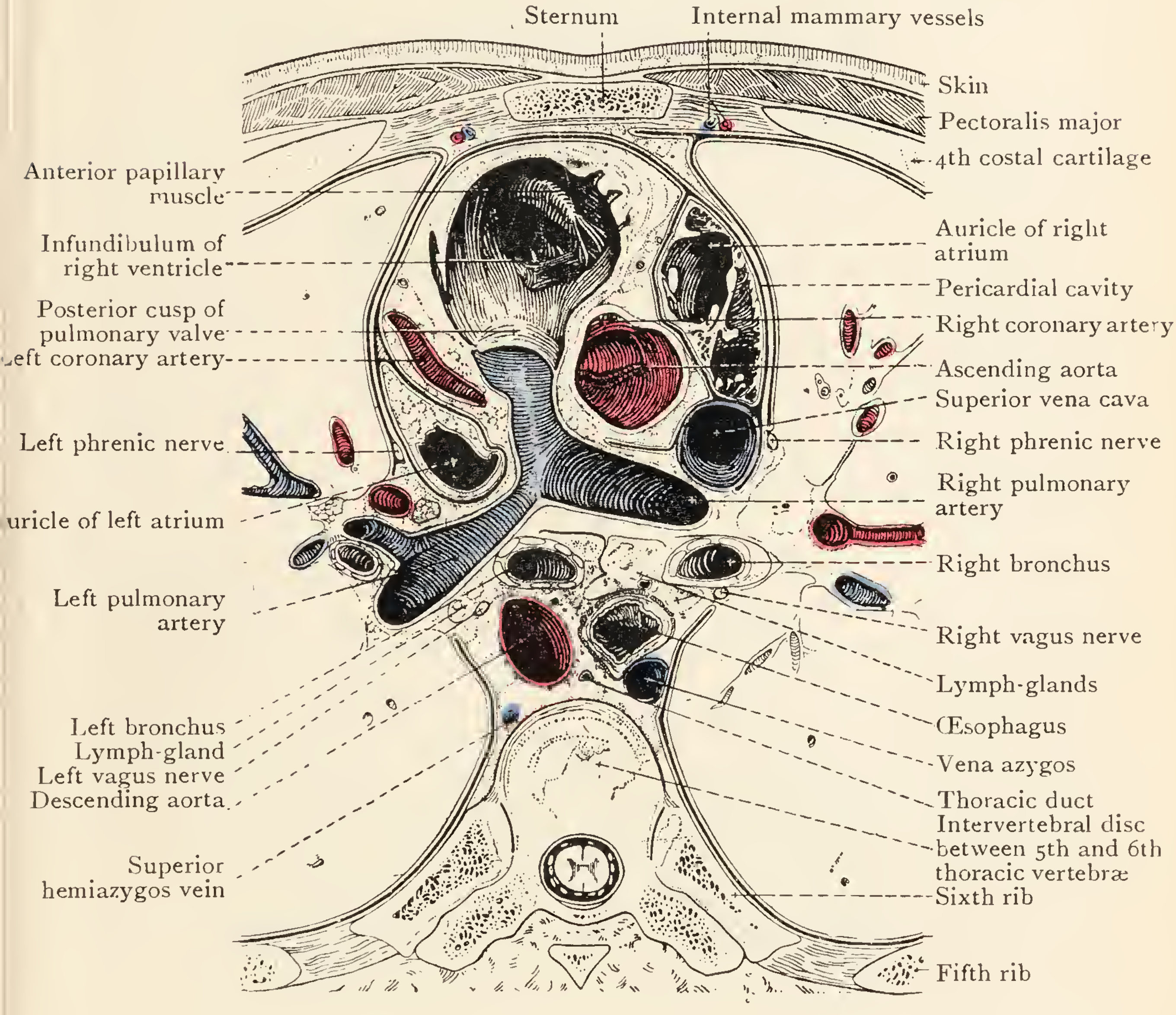


FIG. 26.—Transverse Section through the Thorax of a young man along the plane **C-C**, Fig. 19, p. 39. Seen from above, Cf. Fig. 50, p. 88.

cardium and the root of the lung to become continuous with the descending aorta, its anterior part is separated from the pleura and lung by the fatty tissue around the remains of the *thymus*; but it is more intimately related to the pleura and lung above the root, and makes a wide horizontal groove on the lung immediately above the hilum. The floor of this groove is related also to the structures on the left surface of the arch—*left phrenic*, *left vagus*, two *cardiac nerves* and the *left superior intercostal vein.*

The ascending part of the *left subclavian artery* makes a

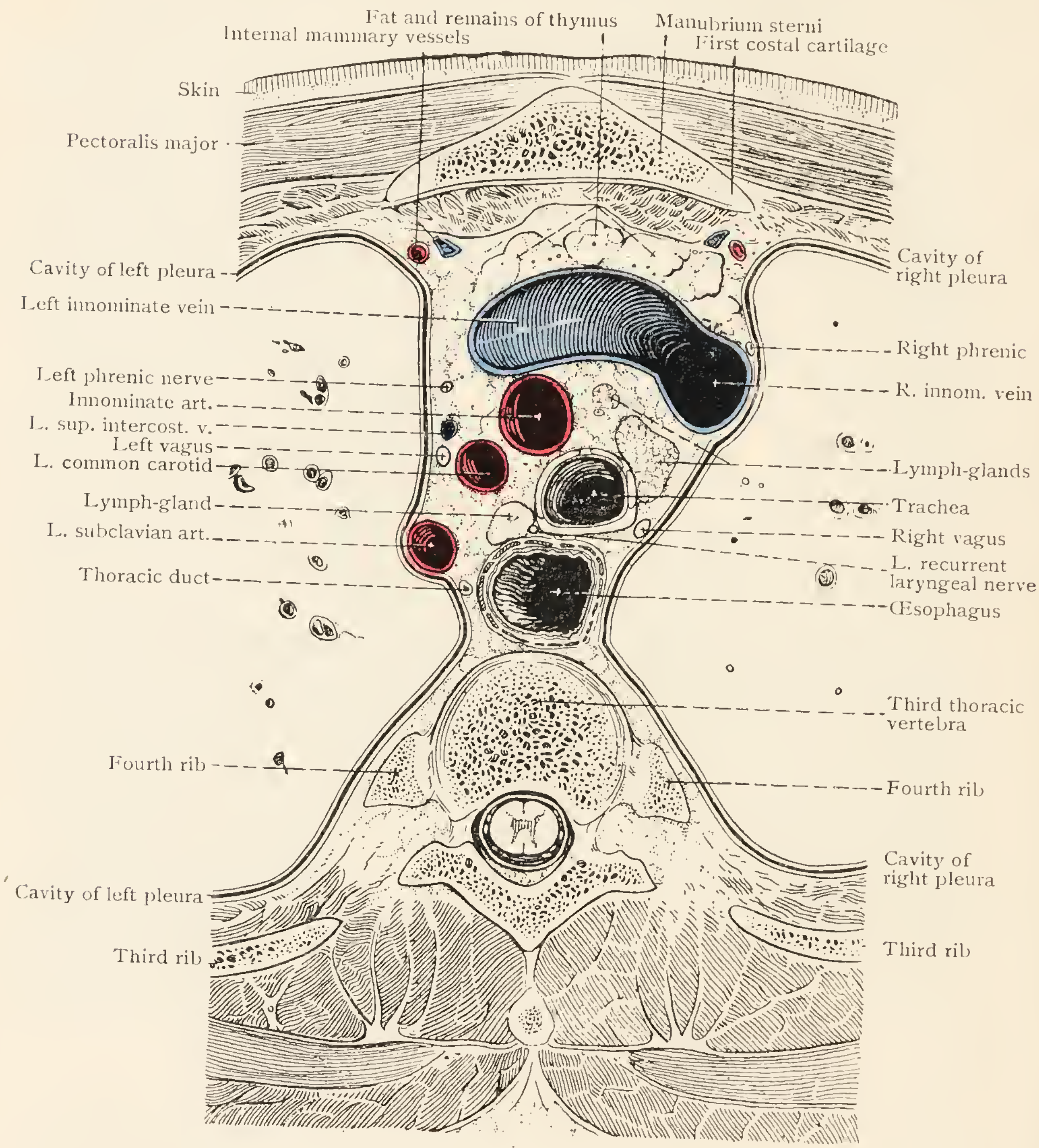


FIG. 27.—Transverse Section of Thorax of a young man along the plane **A-A**, Fig. 19 (cf. Fig. 36, p. 65).
The œsophagus was relaxed and dilated.

narrow, sharply defined groove that runs vertically upwards from the anterior part of the groove for the arch. Behind that groove, there is a fairly wide area related to the *œsophagus*, to the *thoracic duct* on the left side of the œsophagus, and to the *left recurrent laryngeal nerve* in front of the œsophagus (Fig. 36). There is a smaller area in front of the groove for the subclavian artery; that area is related to the *phrenic*, *vagus* and *cardiac nerves* and the *left common carotid artery*; the two arteries and the nerves (and the fat around them) separate the pleura and lung from the left side of the *trachea*.

As on the right side, the phrenic nerve is related to the whole length of the lung as the nerve descends first in front of the subclavian artery, next on the arch of the aorta, and then on the left surface of the pericardium.

Lobes of the Lungs.—The *left lung* is divided into two lobes by a long, deep *oblique fissure* which penetrates its substance to within a short distance of the hilum. The fissure begins at the posterior border about two and a half inches below the summit, at the level of the medial end of the spine of the scapula and the spine of the third thoracic vertebra. It is continued on the lateral surface, in a slightly spiral direction, downwards and forwards, till it cuts the inferior margin opposite the lateral part of the sixth costal cartilage. The *upper lobe* of the lung lies above and in front of the oblique fissure; the apex and the whole of the anterior border belong to it. The *lower lobe* is more bulky than the upper, and lies below and behind the fissure; it comprises almost the entire base and the greater part of the back of the lung.

Two deep fissures divide the *right lung* into three lobes. The *oblique fissure* is similar to the fissure in the left lung; it separates the lower lobe from the upper and middle lobes. The second cleft, called the *horizontal fissure*, begins at the anterior border of the lung at the level of the fourth costal cartilage and extends horizontally till it joins the oblique fissure. The middle lobe, thus cut off from the upper lobe, is wedge-shaped in outline.

The pulmonary pleura extends into the fissures of the lungs and covers the opposing surfaces of the lobes, between which some movement occurs during expansion and contraction. The fissures are, however, often incomplete at birth and may remain so throughout life. It also often happens that the fissures are obliterated by inflammatory exudate, just as adhesion may occur between the pulmonary and the parietal pleura.

Chief Differences between the Lungs.—(1) The right lung is slightly larger than the left, in the proportion of 11 to 10. (2) The right lung is shorter and wider than the left lung. This difference is due to the great bulk of the right lobe of the liver, which elevates the right cupola of the diaphragm to a higher level than the left cupola, and also to the heart and pericardium, which bulge more to the left than to the right and thus diminish the width of the left

FIG. 28.—Transverse Section of Thorax of a young man along the plane **B-B**, Fig. 19.

lung. (3) The anterior margin of the right lung is more or less straight; the corresponding margin of the left lung presents, in its lower part, a marked angular deficiency called the *cardiac notch*. (4) The right lung is subdivided into three lobes, and the left lung into two.

The dissectors must now study the roots of the lungs in detail, using for the purpose the portions of the roots that are still attached to the mediastinum; but, before they proceed to do so, some further dissection is required.

Dissection.—The vagi nerves and slender branches from the thoracic sympathetic ganglia have already been followed to the posterior pulmonary plexuses on each side (p. 32). Now, follow some of the branches of the plexus to the walls of the bronchus. Trace towards the œsophagus other branches which connect the posterior pulmonary plexuses of opposite sides together. Complete the cleaning of the bronchial arteries on the backs of the bronchial tubes.

Radix Pulmonis.—The root of the lung is made up of a number of structures which enter or leave the lung at the hilum. The main structures are:—(1) the *bronchus*, through which air passes to and from the lung; (2) a *pulmonary artery*, which carries venous blood from the right side of the heart to the lung to be oxygenated; (3) two *pulmonary veins*, *upper* and *lower*, which convey oxygenated blood from the lungs to the left side of the heart; (4) *lymph-vessels* and *lymph-glands* through which lymph passes on its way from the lung towards a larger lymph-vessel called the mediastinal lymph-trunk; (5) *bronchial arteries* (accompanied by *veins*)—one artery on the right side, and two on the left side—which carry oxygenated blood from the aorta to the walls of the bronchial tubes (both outside and inside the lungs) and to the lymph-glands and the substance of the lung; (6) the *anterior* and *posterior pulmonary plexuses* of nerves and their branches, which supply the bronchi, the lung substance and the pulmonary pleura.

The structures which compose the root of the lung are enclosed in a layer of pleura which has been removed, and are also bound together by areolar tissue which is often dense and fibrous in the adult, especially around the lymph-glands.

The bronchus is always easily identified by the firm, elastic plates of cartilage which help to form its walls, as well as by its posterior position. The pulmonary artery can be distinguished not only by its position between the bronchus and the veins, but also, as contrasted with the veins, by the greater thickness of its walls. The lymph-glands are easily recognisable in the adult by their dark colour, but in the child they are yellowish-pink in colour and are not so obvious. The bronchial arteries lie on the posterior faces of the bronchi; if they are not well-injected they are difficult to trace, and the veins which accompany them are still more difficult to secure.

One bronchus and one pulmonary artery enter the root, and two pulmonary veins leave it. As the bronchus and artery enter the root, the artery is in front of the bronchus ; but, after they enter the hilum of the lung, the artery passes to the lateral side of the bronchus and then descends behind it. The pulmonary veins lie at a lower level than the bronchus and artery, and the upper pulmonary vein is placed in a more anterior plane than either of them. Before the right bronchus enters the hilum of the lung it gives off a large branch called

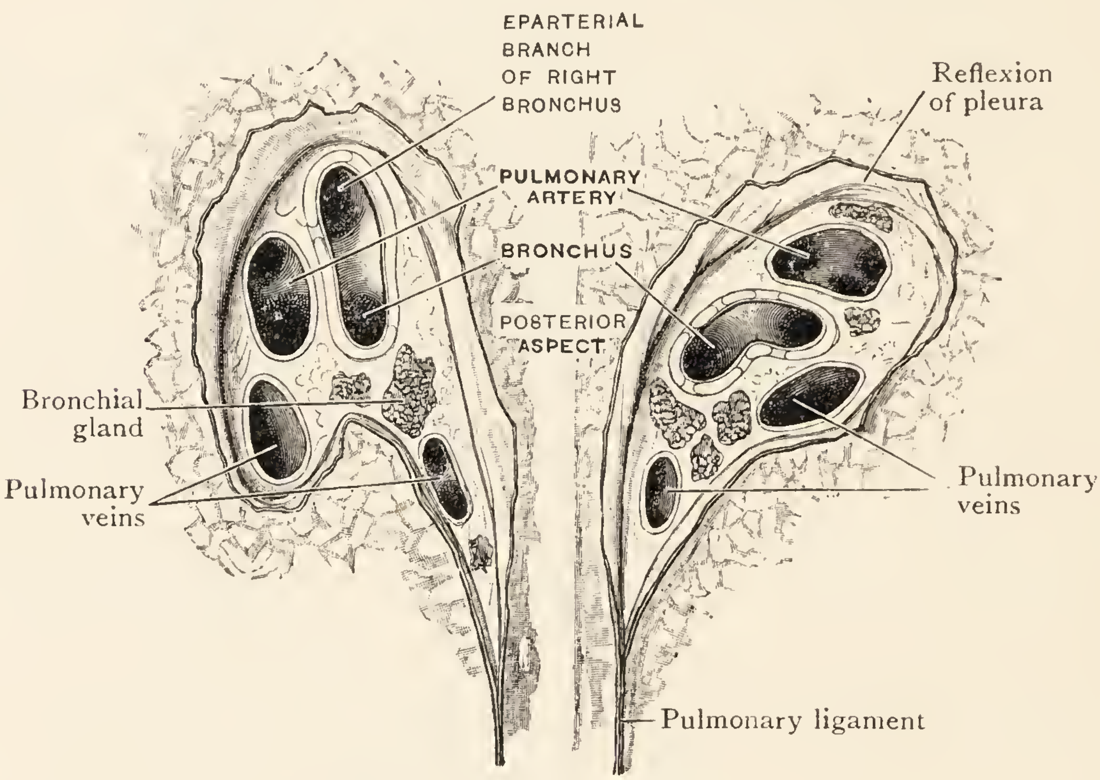


FIG. 29.—The two Pulmonary Roots divided close to the hilum of each lung.

the *eparterial bronchus* because it arises above the level at which the pulmonary artery crosses the front of the main bronchus. There is no corresponding branch from the left bronchus. On both sides the branches given off below the point where the pulmonary artery crosses the main stem bronchus are called *hyparterial bronchi*.

It follows from what has been stated that in sections across the root of the lung, the relative positions of the structures will vary slightly according to whether the section is nearer to the median plane or farther from it ; but in all such sections the upper pulmonary vein will lie in an anterior plane, the bronchus in a posterior plane, and the pulmonary artery between them. If the section is made close to the hilum of the lung, the relationship from before backwards, *on both* *sides*, is upper pulmonary vein, pulmonary artery, stem bronchus. The relationship from above downwards, *on the right side*, is eparterial bronchus, pulmonary artery, hyparterial bronchus, lower pulmonary vein ; and, *on the left side*, pulmonary artery, stem bronchus, lower pulmonary vein—the difference being due to the eparterial branch from the stem bronchus, which is present only on the right side (Figs. 30, 62).

Relations of Roots of Lungs.—The phrenic nerve and the pericardiaco-phrenic vessels are a little distance in front of the root of each lung ; the posterior lip of the hilum is behind the root ; and the pulmonary ligament is below it. In addition :—the superior vena cava is close in front of the upper half of the *right* root and the vena azygos is above it ; the arch of the aorta is immediately above the *left root* and the descending aorta is behind it (Figs. 22, 23).

Bronchi.—There are two primary bronchi, one for each lung. They spring from the termination of the trachea, and each passes downwards and laterally to a lung and enters its substance through its hilum. The parts of the bronchi encountered so far are outside the lung and are called the extrapulmonary bronchi. They are displayed only partially at present, and the study of their special relations must be deferred (see p. 115) ; but the intrapulmonary parts can be examined now.

Before proceeding to the dissection, it is well to read first the following paragraphs on the arrangement of the bronchi and pulmonary vessels, and to study the diagram on p. 54.

Intrapulmonary Bronchi.—These are the parts inside the lung, and an attempt should be made to display them and the vessels in the lung.

As the dissection is pursued, the dissector will find that the main bronchus, having entered the lung, descends in its substance to the base, and, in its descent, is nearer the medial than the lateral surface of the lung and nearer the back of the lung than the front. He will find also that the apex of the lung is supplied by branches which ascend to it, and that the other parts are supplied by branches of the bronchus that run mainly forwards or backwards—many of them having an inclination downwards.

All the bronchi, except the smallest terminal branches, are kept permanently open by bars and plates of cartilage which are embedded in the fibrous tissue in their walls and enable the bronchi to be easily distinguished from the blood-vessels. The layer of fibrous tissue and cartilage is separated from the lining of mucous membrane by the *muscular coat*, which

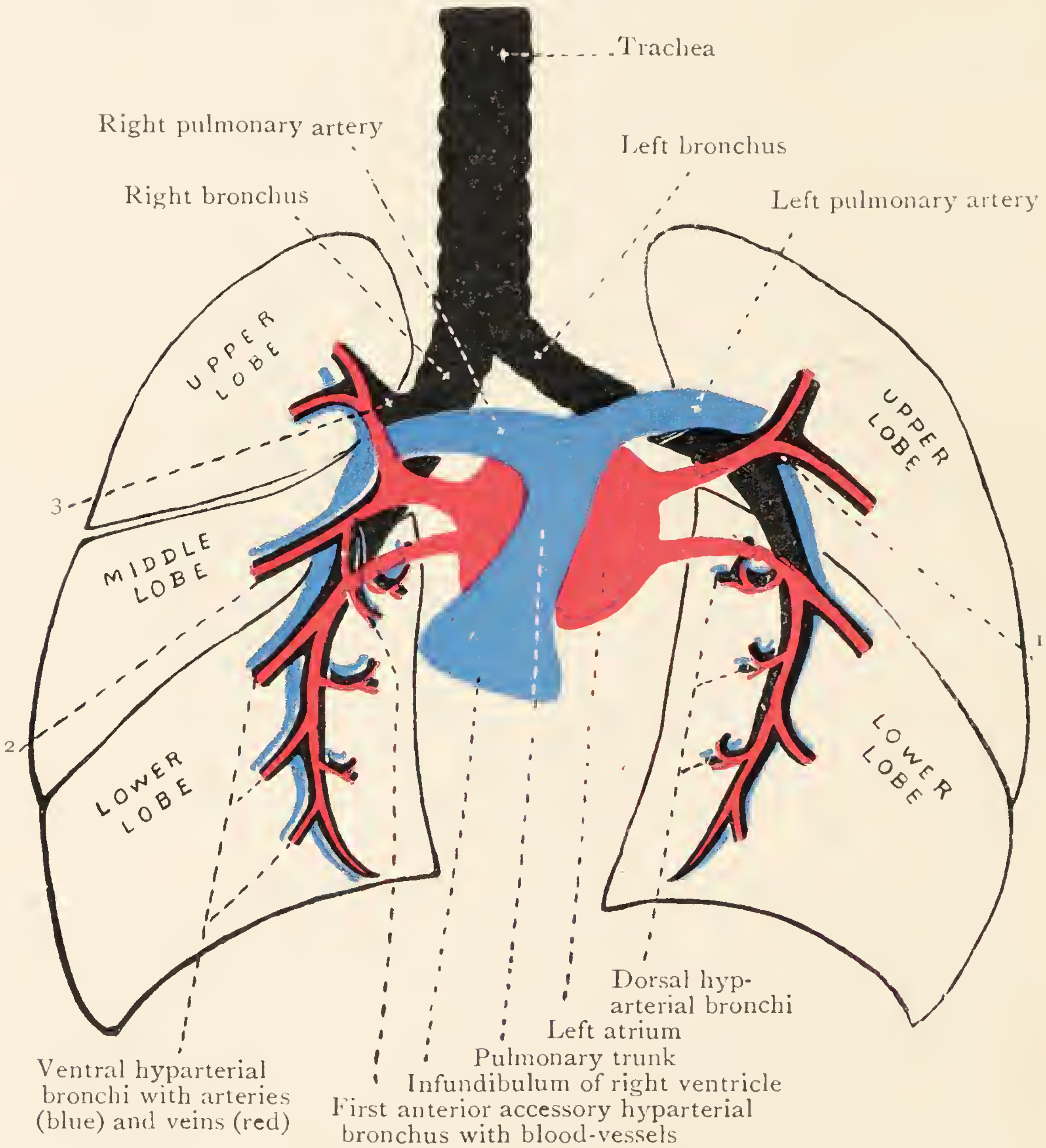


FIG. 30.—Diagram of Lungs with Bronchi and Blood-Vessels.

1, 2. First ventral hyparterial bronchus.
3. Eparterial bronchus.

consists of non-striped muscle-fibres arranged circularly. The lumina of all the bronchi can be reduced in size by the contraction of this bronchial muscle, for none of the bars or plates of cartilage extend completely round the walls of the tubes.

The dissectors should examine Figs. 30, 63, 65. *In the right lung* the eparterial bronchus enters the upper lobe of the lung accompanied by a tributary of the upper right pulmonary vein and a branch of the right pulmonary artery. It is the only bronchus distributed to the upper lobe, and in its substance it breaks up into numerous ramifications, all of which are accompanied by tributaries and branches of the pulmonary vein and artery. Below the eparterial branch, the stem bronchus descends into the lower lobe, and as it descends it gives off a series of ventral and dorsal branches which arise alternately; and each branch is accompanied by a tributary of the pulmonary vein and a branch of the pulmonary artery. The ventral branches spring from the lateral border of the stem bronchus and run towards the anterior margin of the lung; the dorsal branches arise from the back of the stem bronchus and pass towards the back of the lung. The first ventral branch is distributed to the middle lobe, and is accompanied by a tributary of the upper pulmonary vein. All the other hyparterial branches, both ventral and dorsal, are distributed to the lower lobe, and are accompanied by tributaries of the lower pulmonary vein and branches of the pulmonary artery.

The dissector should note that the ventral and dorsal branches arise alternately—first a ventral, then a dorsal—and that there are a few *accessory bronchi* between them. One of these accessory bronchi is of some special interest; it springs from the part of the stem bronchus immediately below the first ventral branch, and is therefore the second branch of the hyparterial part of the stem bronchus. Its special interest is that it is distributed to a portion of lung substance which is occasionally separate as a small accessory lobe corresponding to the *cardiac lobe* of lower mammals. The accompanying artery is frequently a branch of the artery to the middle lobe, and the vein terminates in the vein from the middle lobe.

In the left lung the arrangement of the bronchi is different, owing to the absence of an eparterial bronchus. The first ventral hyparterial branch is relatively very large and is distributed entirely to the upper lobe; it is accompanied by a large branch of the left pulmonary artery and by the upper left pulmonary vein. All the remaining branches are distributed to the lower lobe, and are accompanied by branches of the pulmonary artery and by tributaries of the lower left pulmonary vein.

Pulmonary Blood-Vessels.—One **pulmonary artery** is distributed to each lung. As it passes through the root of the lung it crosses in front of the stem bronchus, and it descends in the interior of the lung, postero-lateral to the stem bronchus, and between its ventral and dorsal hyparterial branches. It gives off branches which correspond to the branches of the bronchus and are distributed with them—chiefly along their posterior surfaces. When the terminal branches of the bronchi—the *bronchioles*—end in the alveolar passages, the final ramifications of the arteries end in capillaries which form a vascular network between the walls of the alveoli. The pulmonary arteries carry venous blood from the right ventricle of the heart to the lungs, where, as the blood runs through the capillaries in relation to the walls of the alveoli, it gives off its excess of carbonic acid gas to the air in the alveoli and receives oxygen from it.

As a rule there are four **pulmonary veins**—an upper and a lower on each side. The number, however, may be increased to five—one from each lobe—or may be reduced to two—one on each side.

The tributaries of the pulmonary veins arise from the capillary plexuses between the walls of the alveoli; they accompany the bronchi, lying, as a rule, along their anterior faces, and they gradually unite together until on each side a terminal venous stem is formed in each lobe. The stems from the upper and middle lobes on the *right side* fuse together to form the upper right pulmonary vein. The vein from the upper lobe accompanies the eparterial bronchus, and the vein from the middle lobe accompanies the first ventral hyparterial bronchus. The upper right pulmonary vein receives tributaries also from the medial part of the lower lobe or from the cardiac lobe when it is separate. On the *left side* the stem from the upper lobe forms the upper pulmonary vein. On *both sides* the stem from the lower lobe forms the lower vein ; on the right side it receives tributaries which correspond to all the hyparterial bronchi, except the first ventral and the first ventral accessory ; on the left side it receives all the veins from the lower lobe.

The pulmonary veins carry arterial (oxygenated) blood from the lungs to the left atrium of the heart, whence it passes to the left ventricle and is then distributed by the aorta to all parts of the body.

Dissection.—Place the lung with its medial surface uppermost. Follow the pulmonary veins into its substance ; they lie in front of the main parts of the bronchi. *On the right side*, begin with the upper pulmonary vein and find its tributaries from the upper and middle lobes, and from the medial part of the lower lobe. As the vein and its tributaries are cleaned, clean also the anterior surfaces of the bronchi. Next, follow the inferior pulmonary vein, which receives tributaries from the lower lobe only. After the veins have been cleaned, follow the eparterial bronchus for a short distance into the substance of the upper lobe and note that it is the only bronchus distributed to that lobe. Now, clean the hyparterial bronchus and attempt to display its two main sets of branches—*ventral* and *dorsal*. As the bronchi are being cleaned small *pulmonary lymph-glands* will be met with in the angles between their branches. They will be recognised in the adult by their black or greyish-black colour. As the dissection proceeds, the dissector will find some small *accessory bronchi* between the ventral and dorsal branches.

After the bronchi have been cleaned, follow the intrapulmonary part of the pulmonary artery, as it descends along the postero-lateral side of the stem bronchus, between the ventral and dorsal hyparterial branches, and note that its branches correspond with the branches of the bronchus and run chiefly along their posterior surfaces.

On the left side the arrangement is less complicated. Follow first the pulmonary veins—the upper to the upper lobe, the lower to the lower lobe. Then, clean the stem bronchus and its ventral and dorsal branches ; and, finally, follow the pulmonary artery along the postero-lateral face of the stem bronchus, as in the right lung.

Bronchial Vessels.—As a rule, two bronchial arteries are distributed to the left lung and one to the right lung. The two left bronchial arteries spring from the descending aorta. The right bronchial artery is a branch either of the first right aortic intercostal artery or of the upper left bronchial artery. The bronchial arteries and their branches run along the posterior surfaces of the bronchi and their branches, and are the proper nutrient vessels of the lungs. A variable quantity of the blood they convey to the lungs is returned by the pulmonary veins to the left atrium and the remainder is returned by bronchial veins, which open on the right side into the vena azygos, and on the left side into the superior hemiazygos vein, or into the left superior intercostal vein.

Lymph-Vessels and Lymph-Glands of Lung. — The lymph-vessels of the lungs cannot be displayed in an ordinary part, but the *bronchial lymph-glands*, on account of their blackness and the dense fibrous tissue which binds them to the adjacent bronchi and blood-vessels, are disagreeably obvious, for they considerably increase the difficulties of the dissector who is attempting to clean the constituent parts of the root of the lung and the bronchi.

The lymph-vessels of the lung convey lymph from the substance of the lung to the *pulmonary lymph-glands*, which lie in the substance of the lung in the angles between the branches of the bronchial tubes. Having passed through the pulmonary lymph-glands, the lymph is carried onwards, by their efferent vessels, to the *broncho-pulmonary lymph-glands*, which lie in the hilum of the corresponding lung in the angles between the stem and the highest branches of the bronchus. The broncho-pulmonary lymph-glands receive lymph directly from the pulmonary pleura also. From the broncho-pulmonary lymph-glands the lymph passes to the *superior tracheo-bronchial lymph-glands*, which lie in the angle between the bronchus and the side of the trachea; and to the *inferior tracheo-bronchial lymph-glands*, which are placed in the angle between the two bronchi and receive lymph from both lungs. The tracheo-bronchial glands are connected with the posterior mediastinal and innominate glands by intercommunicating lymph-vessels. From the right tracheo-bronchial glands the greater part of the lymph passes by the right mediastinal trunk to the right innominate vein, but some may be carried to the deep cervical glands which lie at the root of the neck behind the right sterno-mastoid muscle. The lymph from the left tracheo-bronchial glands flows to the thoracic duct and the left deep cervical glands, or directly to the left innominate vein by the left mediastinal trunk. The lymph from the inferior tracheo-bronchial glands flows partly to the mediastinal trunks and partly to the thoracic duct.

The pulmonary, the broncho-pulmonary, and some of the tracheo-bronchial lymph-glands were seen as the root of the lung and the bronchi were dissected. The remaining tracheo-bronchial lymph-glands cannot be displayed until the heart has been dissected.

The superficial cardiac plexus should be dissected and examined now, lest it be destroyed in the subsequent examination of the structures in the mediastinum.

Dissection.—Find the *left recurrent laryngeal nerve* on the side of the aortic arch ; trace it medially below the arch, and identify a short fibrous cord—the *ligamentum arteriosum*—which is attached to the arch immediately in front of the nerve. Do not clean the ligament at present, but turn to the cardiac nerves that lie on the left side of the aortic arch. They have been found already (p. 33). Trace them now into the concavity of the arch immediately in front of the ligamentum, where they end in the *superficial cardiac plexus*. Clean the plexus as far as possible, and trace filaments from it upwards, downwards and sidewards.

Then, clean the ligamentum arteriosum and find its connexion with the root of the left pulmonary artery.

Superficial Cardiac Plexus.—This is a small plexus of slender nerves that lies in front of the ligamentum arteriosum below the arch of the aorta and on the bifurcation of the pulmonary trunk.

It is formed by the superior cervical cardiac branch of the left sympathetic trunk and the inferior cervical cardiac branch of the left vagus.

It sends branches :—(1) upwards and backwards to the deep cardiac plexus, which lies near it on the bifurcation of the trachea ; (2) downwards along the pulmonary trunk to the heart ; and (3) towards the left to the left anterior pulmonary plexus, which lies in the front of the root of the lung (p. 118).

Structures in Mediastinum.—It has been pointed out that the mediastinum is the region between the two pleural sacs, and that it is occupied by some of the most important viscera and vessels and nerves in the body. The chief among these are :—the heart, enclosed in the pericardium ; the great vessels that carry the blood to and from the heart, including the aorta and its great branches ; the œsophagus and trachea ; the vagi and phrenic nerves ; and the thoracic duct. It was noted, further (p. 17), that the mediastinum is separated, for descriptive purposes, into four mediastina—superior, anterior, middle and posterior. The contents of these mediastina must now be examined in detail.

> ***Dissection.***—Divide the remains of the superior and anterior mediastinal parts of the pleura longitudinally, immediately behind the sternum, from the lower end of the thorax to the apices of the pleural sacs. Cut through the first pair of costal cartilages close to the manubrium sterni, and, at the same time, separate the sternal head of each sterno-mastoid muscle from the manubrium, if that has not already been done by the dissectors of the Head and Neck. Then, divide the sterno-hyoid and sterno-thyroid muscles transversely, as close to the upper margin of the manubrium as possible. Next, separate the body of the sternum from the xiphoid process and the tips of the seventh pair of costal cartilages. Remove the sternum with the attached costal cartilages, but *preserve them carefully for future use.*

Relation of Sternum to Vertebral Column.—Before the sternum is laid aside, count the ribs from above downwards in the posterior part of the thorax, and, by means of the ribs, identify the thoracic vertebræ—especially the *second*, *fifth* and *ninth*. Replace the sternum and note the vertebræ which it is opposite.

In a young man of average build, the *upper border of the manubrium* is usually opposite the disc between the second and third thoracic vertebræ ; the *sternal angle* (at the junction of manubrium and body of sternum) is opposite the upper border of the body of the fifth, and therefore at the level of the interval between the third and fourth thoracic spines ; and the *xiphi-sternal joint* is opposite the body of the ninth vertebra and the eighth spine, but may be one vertebra lower.

In the description of the topography of the contents of the

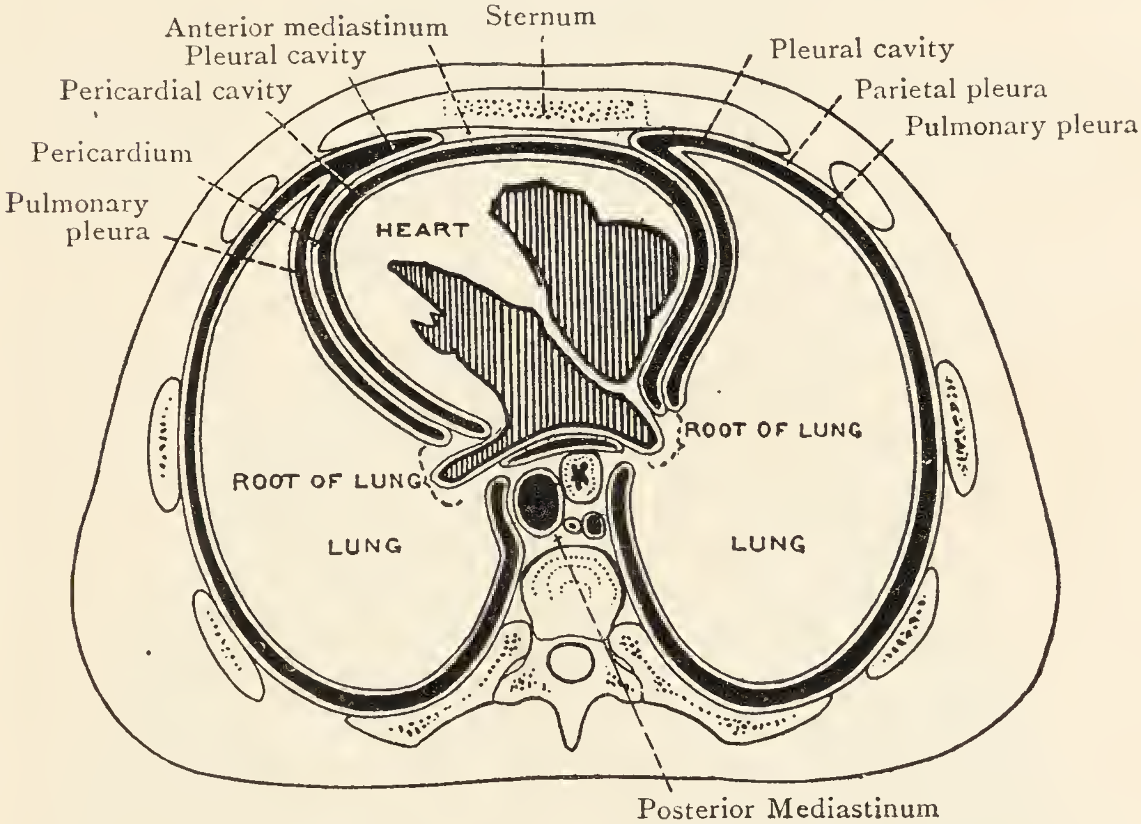


FIG. 31.—Diagram of Cross-Section of Thorax to show the Mediastina. The heart and pericardium occupy the middle mediastinum.

mediastina, it is assumed that these levels are maintained. But, in elderly people, there is a tendency for the sternum and mediastinal contents to droop (Fig. 35) ; and the dissectors must not be surprised to find that the relations of parts in the body under dissection are not quite the same as those described—the more so as relations are modified also by pathological curvatures of the backbone, disease of the lungs and dilatation of the heart and aorta, which are all common in the dissecting-room cadavera.

When the sternum is removed, the mediastinal septum is exposed from the front. As seen from the front, the superior mediastinum, which is the part behind the manubrium, is a relatively wide area. The anterior mediastinum is behind the body of the sternum, and is a narrow cleft except opposite the

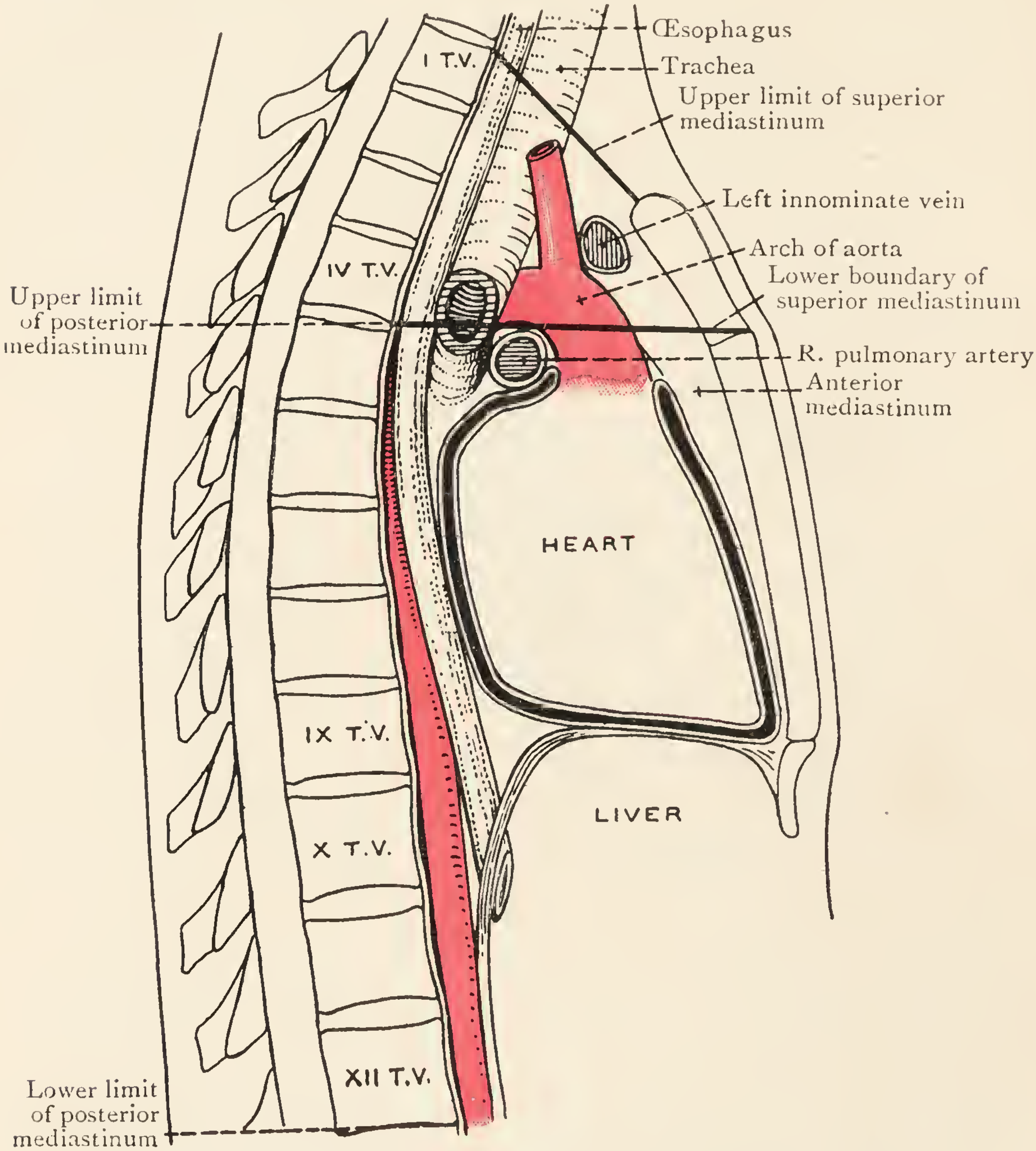


FIG. 32.—Diagram of Parts of Mediastinum in Median Section.
The heart and pericardium occupy the middle mediastinum. The pericardium forms the posterior boundary of the anterior mediastinum and part of the anterior boundary of the posterior mediastinum.

anterior end of the fifth left costal cartilage, where the left pleural sac deviates slightly to the left (Fig. 34).

Thymus.—The anterior mediastinum and the anterior part of the superior mediastinum are occupied by areolar tissue in which remains of the thymus may be found as far down as the level of the third or fourth costal cartilages. It may be recognised by its position (Figs. 27, 28) and by its firmness compared with that of the surrounding fat; and an endeavour should be made to demonstrate its pair of lobes.

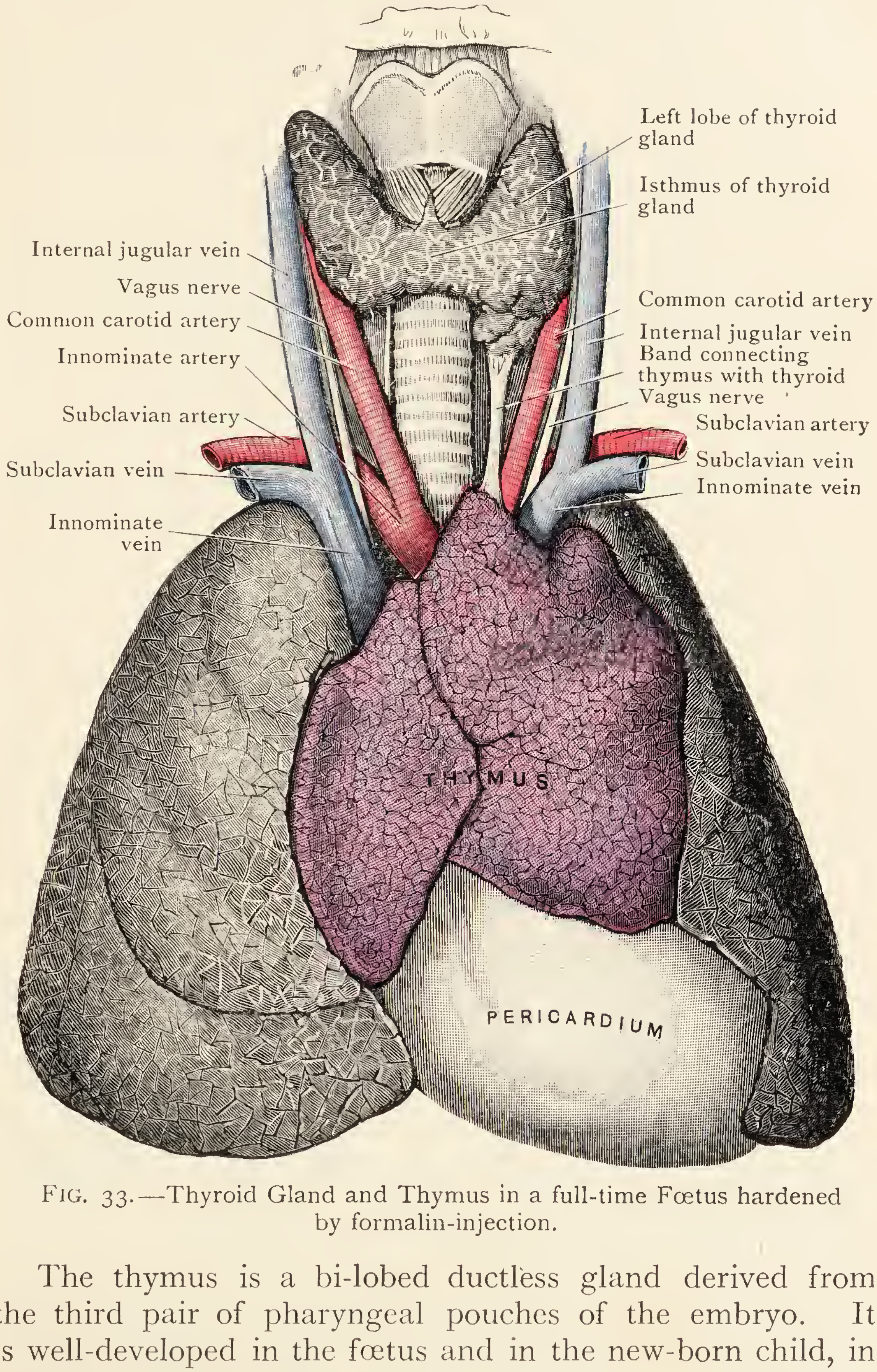


FIG. 33.—Thyroid Gland and Thymus in a full-time Fœtus hardened by formalin-injection.

The thymus is a bi-lobed ductless gland derived from the third pair of pharyngeal pouches of the embryo. It is well-developed in the fœtus and in the new-born child, in which it is nearly as big as the heart (Fig. 33); it continues to grow until puberty, when it reaches the height of its development. Thereafter, it usually undergoes atrophy ; but the extent to which this occurs is very variable, and remnants of the organ may be recognised even until old age.

> ***Dissection.***—Remove the thymus and the remains of the mediastinal pleura, and clean the anterior contents of the superior mediastinum and the front of the pericardium. Begin with the *innominate veins* and trace them from the inlet of the thorax to the superior vena cava, and then clean their tributaries.

Innominate Veins.—There are two innominate veins—a right and a left. Each of them begins behind the clavicle, near its medial end, by the union of the internal jugular and subclavian veins ; and they end behind the lower border of the first right costal cartilage by uniting with each other to form the superior vena cava.

Course and Relations.—The *right innominate vein* is short and its course is almost vertical (Figs. 19, 34). It is accompanied on its medial side by the innominate artery ; in the thorax, the right phrenic nerve runs along its lateral side (Figs. 17, 36), and, antero-laterally, it is in relation with the anterior part of the right pleura.

The *left innominate vein* is much longer than the right. In the thorax, it passes obliquely to the right and downwards, behind the upper half of the manubrium sterni, the lower ends of the sterno-hyoid and sterno-thyroid muscles and the remains of the thymus, and in front of the left common carotid and innominate arteries (Figs. 27, 32, 36).

Tributaries.—(1) Internal jugular, (2) subclavian, (3) vertebral, (4) internal mammary, (5) first posterior intercostal, and (6) inferior thyroid. In addition, the right vein receives the right lymphatic duct, or separate lymph-trunks from the right upper limb and the right half of the head and neck and thorax ; and the left innominate vein receives (*a*) the left superior intercostal vein, (*b*) some pericardial and thymic (mediastinal) veins, and (*c*) the thoracic duct and the left mediastinal lymph-trunk.

On each side, the vertebral and first intercostal veins enter the back of the innominate vein.

On the right side, the inferior thyroid vein enters at the medial border and the internal mammary joins the front.

On the left side, the internal mammary and the superior intercostal vein enter the lower border, and the inferior thyroid enters the upper border.

Not uncommonly, the right and left inferior thyroid veins unite at the root of the neck to form a common trunk which terminates frequently in the left innominate vein, but may end in the junction of the two innominate veins or in the right innominate vein.

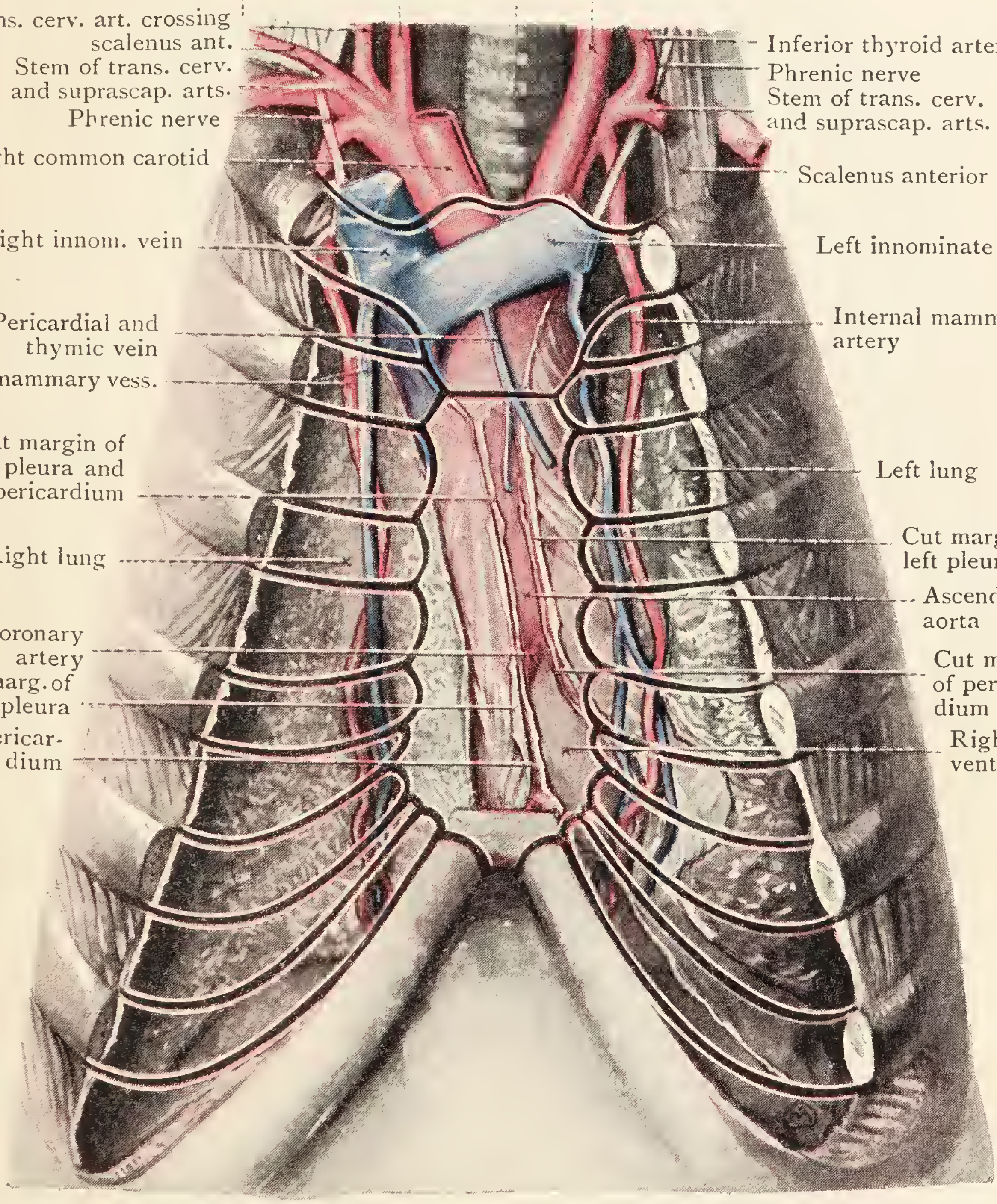


FIG. 34.—Dissection of Anterior Part of Thorax.

The sternum and costal cartilages were replaced in position after the dissection had been made. The right scalenus anterior is cut away from its insertion up to the level of the upper border of the subclavian artery.

Dissection.—Displace the left innominate vein upwards or downwards, and clean the *innominate artery*. Then, clean the *left subclavian* and *common carotid arteries*, taking care not to injure the four nerves which descend between them and have been identified in an earlier dissection (p. 33) ; and, next, clean the *arch of the aorta*. Then, carefully remove the areolar tissue which lies between the innominate and left common carotid arteries and display the *trachea*. Occasionally a small artery—the *thyreoidea ima*—is found ascending on the front of the trachea from the innominate artery.

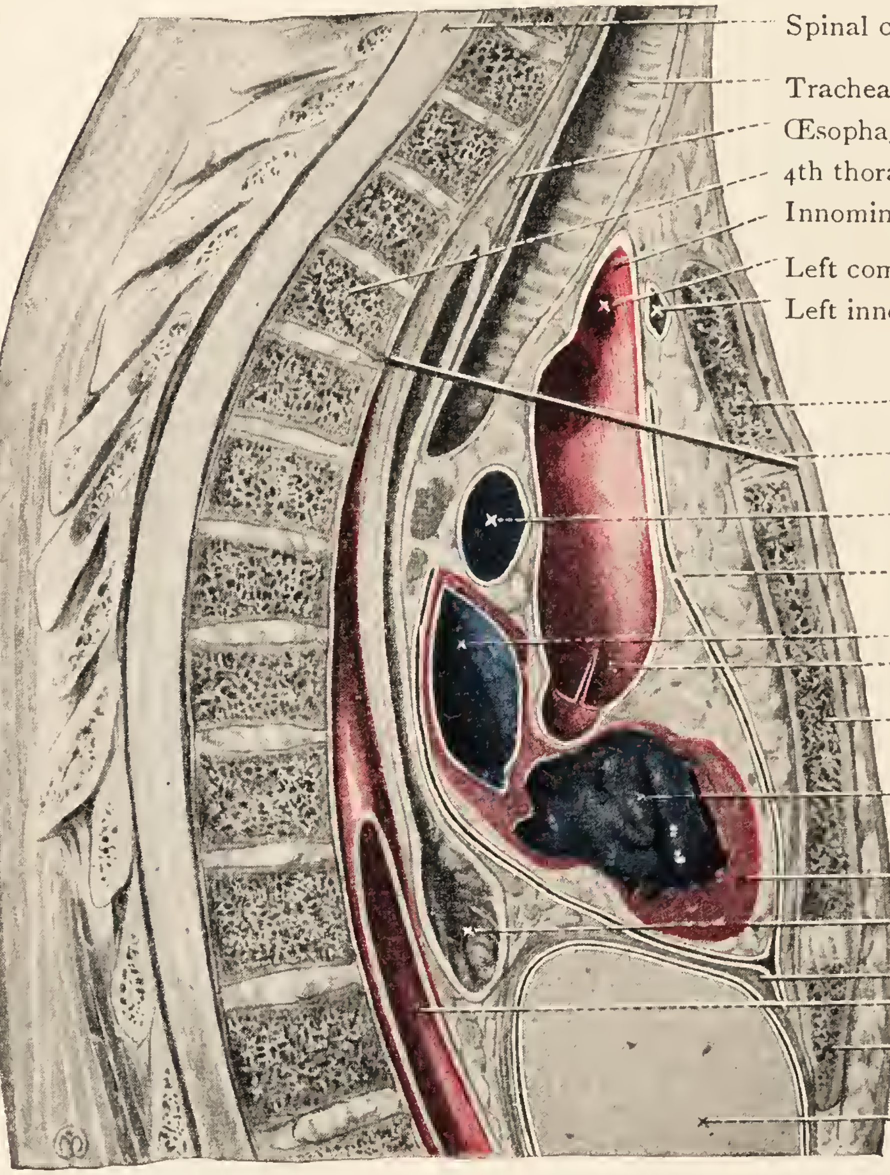


FIG. 35.—Sagittal Section of Thorax of an old man.

The upper border of manubrium sterni and the bifurcation of trachea are lower than in a young adult. The thick black line is the artificial boundary that separates the superior mediastinum from the other three.

Proceed now to the study of the structures exposed.

BRANCHES OF ARCH OF AORTA.—Three large arteries spring from the upper border of the arch—the innominate, the left common carotid and the left subclavian—and are distributed mainly to the head, neck and upper limbs.

Innominate Artery.—This is the first and widest of the three branches of the arch. It begins opposite the centre of the manubrium sterni (Fig. 40), passes upwards and to the right, and ends in the neck, behind the upper border of the right sterno-clavicular joint, by dividing into the right common carotid and the right subclavian arteries (Fig. 34). As a rule

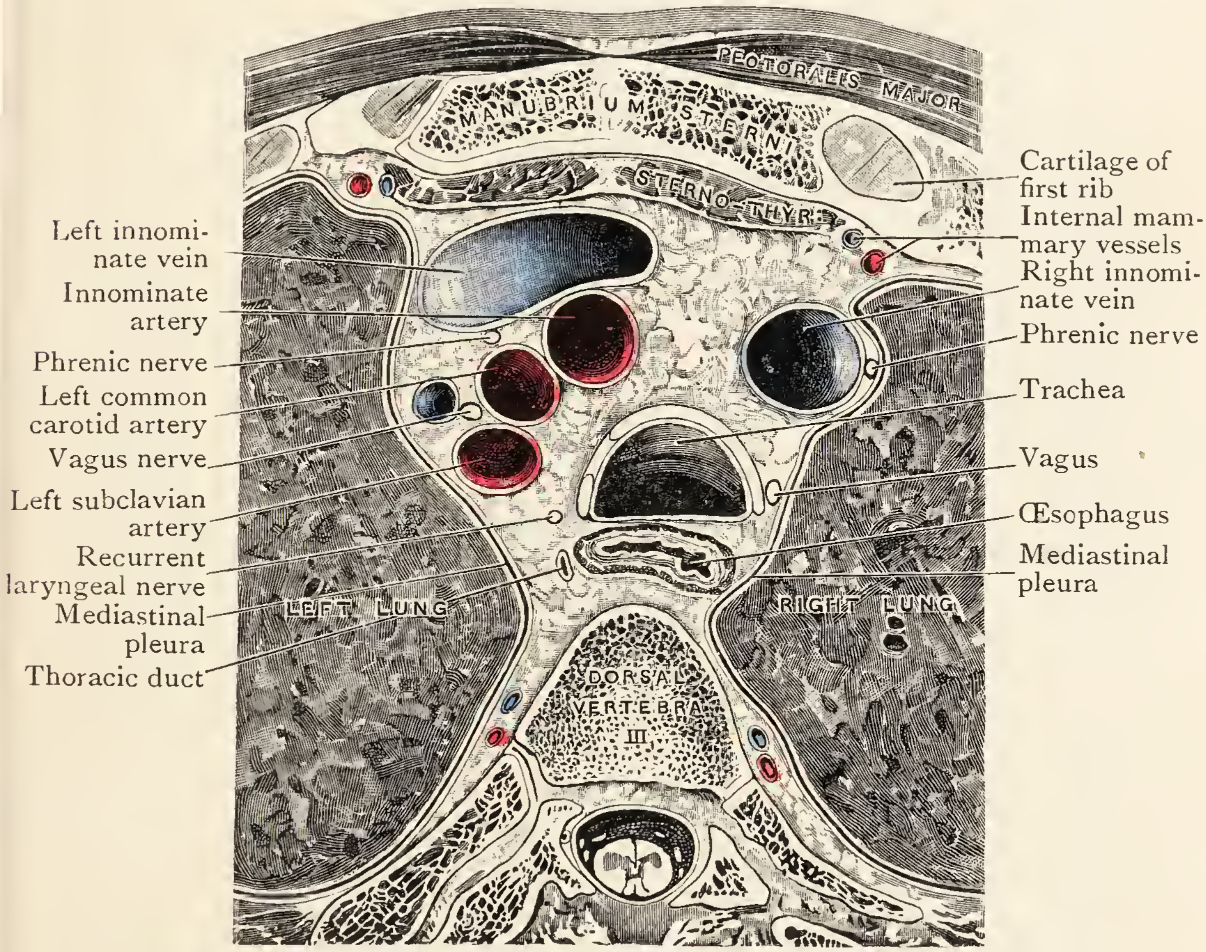


FIG. 36.—Transverse Section through Superior Mediastinum at the level of third thoracic vertebra (cf. Fig. 27, p. 48).

it has no other branches, but occasionally a small artery, called the *thyreoidea ima*, springs from it.

Relations.—Anterior to it, there are the manubrium sterni (with the attachments of the sterno-hyoid and sterno-thyroid muscles), the right sterno-clavicular joint, the remains of the thymus, and the left innominate vein. The trachea is behind its lower part (Figs. 35, 36), but as the artery passes upwards and to the right it gains the side of the trachea and has the upper part of the right lung and pleura behind it. To its left, at its origin, there is the left common carotid artery, and, at a higher level, the trachea. The right innominate vein is on its right side and separates it from the right phrenic nerve and the pleura.

Arteria Thyreoidea Ima.—This artery is seldom present. When present, it springs from the innominate artery or from the arch of the aorta, and ascends over the front of the trachea to the isthmus of the thyroid gland.

Left Common Carotid Artery.—This artery arises immediately to the left of the innominate artery, and also slightly behind it because of the backward direction of the arch. It passes upwards at first on the front of the trachea and then on its left side, and enters the neck behind the left sterno-clavicular joint. It gives off no branches in the thorax.

Relations.—Its anterior relations in the thorax are similar to those of the innominate artery (Figs. 27, 36). At first the trachea is behind it, and then the left subclavian artery. Its medial relations are first the innominate artery and then the trachea. The left pleura and lung are lateral to it; the left phrenic and vagus nerves are between it and the pleura (Fig. 18), but their position varies slightly (Fig. 36).

Left Subclavian Artery.—The left subclavian artery springs from the posterior part of the aortic arch a little behind the left common carotid. It passes vertically upwards to enter the neck opposite the left sterno-clavicular joint, but some distance behind it. Like the common carotid, it has no branches in the thorax.

Relations.—The left pleura and lung are lateral to it and are so closely related that it grooves the lung. The left common carotid artery and the left phrenic and vagus nerves are in front of it. The trachea is medial to it (Fig. 36). Posteriorly, it is related to the pleura and lung, and, more medially, to the margin of the œsophagus, together with the left recurrent laryngeal nerve and the thoracic duct; but these three structures come to be medial to it as it enters the neck (Fig. 27), and, there, the pleura and lung are more fully behind it.

The dissectors will now leave the superior mediastinum for a time and turn to the middle mediastinum, whose chief occupants are the pericardium and the heart. The pericardium has been cleaned already, and its arrangement and connexions should now be examined attentively.

Pericardium.—The pericardium is a fibro-serous sac which surrounds the heart and parts of the great vessels which enter and leave the heart. It has three layers:—(1) The fibrous pericardium externally. (2) The parietal layer of the serous pericardium, which lines the inner surface

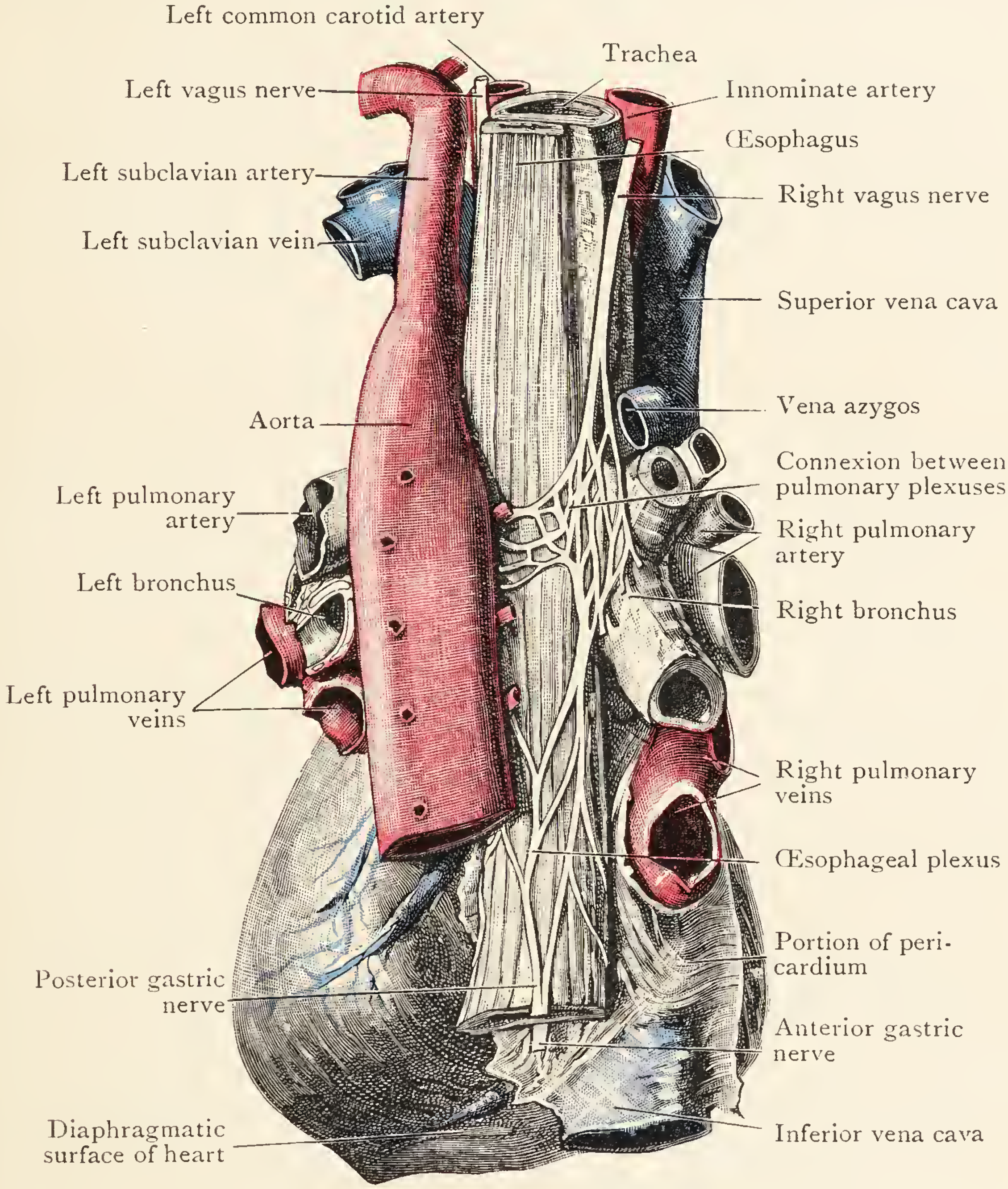


FIG. 37.—Posterior aspect of Heart, with Descending Aorta, Trachea and Bronchi, and Œsophagus.

of the fibrous pericardium and is adherent to it. (3) The visceral layer of the serous pericardium. This layer clothes the heart and the great vessels near the heart; it is separated from the parietal layer by a capillary interval that contains lymph; and it is continuous with the parietal layer at the upper and back part of the pericardium.

The **fibrous pericardium** is a thin sac of strong fibrous tissue, and it is conical in form. Its *apex* is pierced by the aorta, the pulmonary trunk and the superior vena cava, and blends with their sheaths. Its *base* rests on the diaphragm. Near the median plane it is fused with the central tendon, and can be separated from it only by the knife; more laterally the areolar tissue which connects the diaphragm and the pericardium can be easily broken down. Its right posterior part is pierced by the inferior vena cava, and fuses with its sheath. The diaphragm separates the pericardium mainly from the liver, but also, towards the left and anteriorly, from the fundus of the stomach.

Relations.—The pericardium is behind the body of the sternum and the cartilages of the ribs from the second to the sixth inclusive, but its *anterior surface* is separated from them by the lungs and pleuræ, except (1) in the median plane, where two condensations of mediastinal areolar tissue, called the *sterno-pericardial ligaments*, connect the anterior surface of the fibrous sac to the upper and lower parts of the body of the sternum, and (2) in the region of the sternal extremity of the fifth left costal cartilage, where the left pleura retreats towards the left side, and the pericardium comes into direct relation with the sternum and the left sterno-costalis muscle. That portion of the pericardium is the medial part of the **bare area of the pericardium**, which is so named because, owing to the cardiac notch of the left lung, it has no covering of lung (Figs. 11 and 26). This medial part of the area is devoid of pleural covering also; it is usually of small extent, and frequently it does not extend beyond the margin of the sternum; but it is of importance because through it the surgeon may, without risk to the pleura, tap the pericardium when it is distended with fluid.

Each *side wall* of the pericardium is in relation with the mediastinal pleura—the phrenic nerve and the pericardiacophrenic vessels intervening (Figs. 25, 26). The median part of the *posterior surface* is in front of the descending aorta and the œsophagus, but the lateral part, on each side, is supported by the pleura and lung (Fig. 25). At the junction of the upper parts of the lateral and posterior surfaces, on each side, two pulmonary veins enter the pericardium and receive sheaths from its fibrous wall.

The dissectors will now open the pericardium in order to explore its interior and examine the front of the heart.

> ***Dissection.***—Make a vertical cut through each side of the pericardium immediately in front of the line of the phrenic nerve. Join the lower parts of the two vertical incisions by a cross-cut an inch above the diaphragm. Throw the flap upwards.

The **serous pericardium** is a closed and invaginated sac which lines the inner surface of the fibrous sac and envelops the heart and the parts of the great vessels that are inside the pericardium.

The uninvaginated portion, which lines the inner surface of the fibrous sac, is called the *parietal layer* ; the invaginated portion, which envelops the heart and more or less covers the great vessels, is the *visceral layer* or *epicardium*. The opposed surfaces of these two layers are covered with endothelium ; when healthy, they are smooth and glistening, and are separated merely by a thin layer of serous fluid which lessens friction between the two surfaces as they move over each other during the contractions and expansions of the heart. The arrangement is exactly similar to that of the parietal and pulmonary layers of the pleural sac.

Sterno-Costal Surface of Heart.—The heart has been exposed by the reflexion of the anterior wall of the pericardium ; and, before the dissectors disturb it, they will examine the parts of it that are visible, and then study their relations to the anterior wall of the thorax.

Find an oblique sulcus, called the *atrio-ventricular groove*, which divides the anterior or sterno-costal surface into two parts—a part above and to the right composed of the two atria of the heart, and a part composed of the two ventricles below and to the left (Figs. 38, 39). The lower or right part of the groove is quite distinct, but the upper or left part is masked by the roots of the pulmonary trunk and the aorta.

The ventricular part of the sterno-costal surface terminates on the left and below in the *apex* of the heart ; and it is divided by the *anterior interventricular groove* into a right two-thirds formed by the right ventricle and a left third formed by the left ventricle. A line of fat indicates the position of this groove, and the vessels that may be seen in it through the fat are named the great cardiac vein and the anterior interventricular artery. The groove ends inferiorly in a slight notch on the lower border of the sterno-costal surface near the apex. The apex is formed therefore entirely by the left ventricle. The *lower border* of the sterno-costal surface is a sharp margin wedged in between the diaphragm and the anterior wall of the thorax; it is formed almost en-

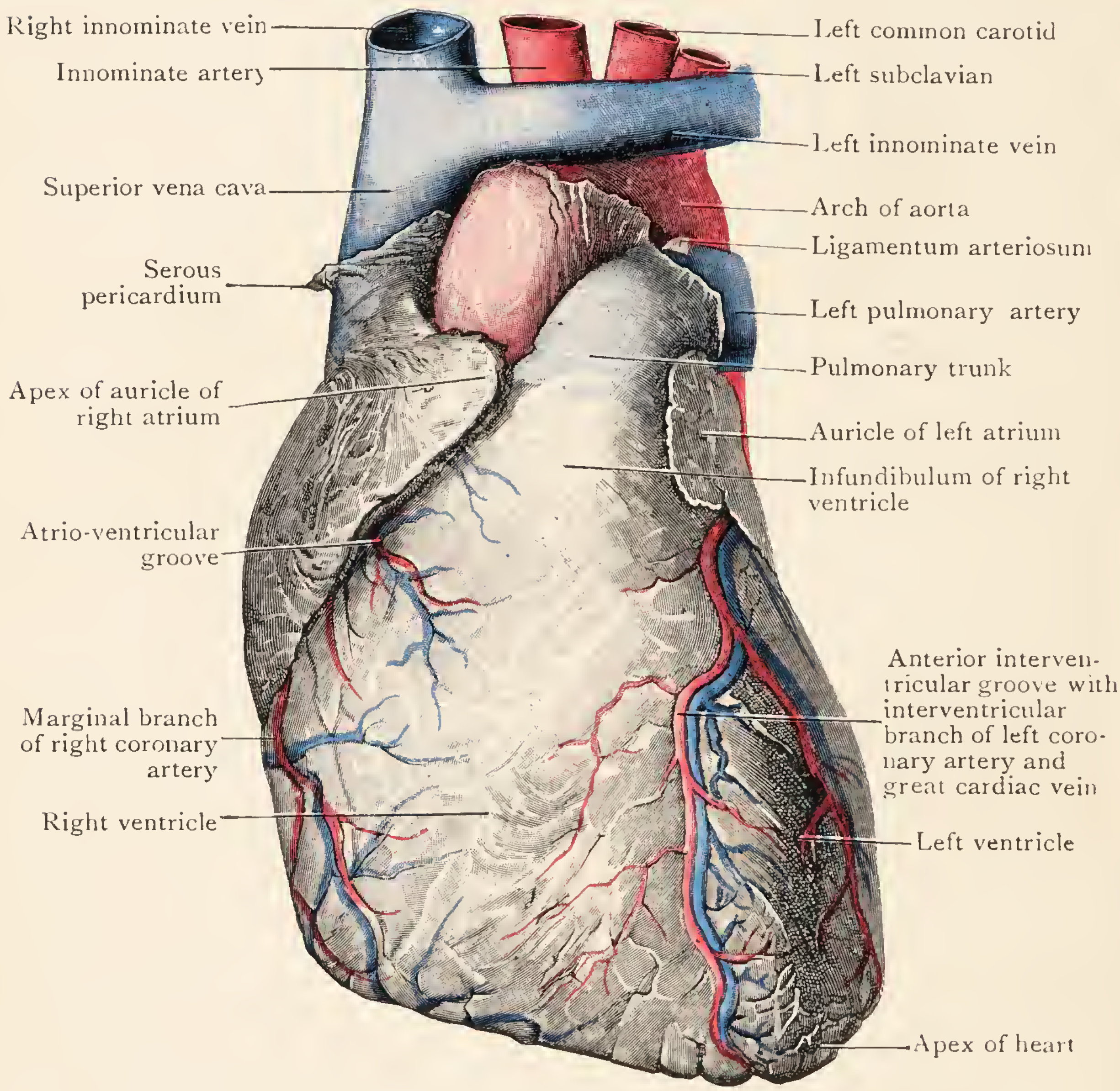


FIG. 38.—Sterno-Costal Surface of Heart.

tirely by the right ventricle, and only to a very small extent by the apical part of the left ventricle.

The *atrial portion* of the surface is to a large extent concealed by the pulmonary trunk and the ascending aorta. To the right and above, there is the right atrium, continuous above with the superior vena cava and below with the inferior vena cava (Fig. 39), whilst its auricle curves upwards and to the left immediately above the atrio-ventricular groove, and reaches the root of the pulmonary trunk.

The whole of the *right border* of the heart is formed by the right atrium, and it is slightly convex. The *left border* is more convex; nearly the whole of it is formed by the left ventricle, but its uppermost part is the auricle of the left atrium. The apex of this auricle is at the upper and left corner of the atrial area; and between the two auricles there are the lower parts of the pulmonary trunk and ascending aorta—the trunk in front of the aorta. It has been explained already that the part of the right ventricle immediately below the pulmonary trunk is called the *infundibulum* because of its funnel-shaped appearance.

If the pulmonary trunk and the ascending aorta were removed, the upper parts of the anterior surfaces of the right and left atria would be exposed, and the *upper border* of the heart, which is formed by the two atria, could be seen. The two large vessels must not, however, be interfered with at present; but the dissectors will investigate the cleft which separates these great arteries from the atria. It is called the *transverse sinus of the pericardium* (Figs. 41, 42).

Transverse Sinus of Pericardium.—To find this sinus, pass a finger across the front of the lower part of the superior vena cava and behind the ascending aorta, and push it to the left until it emerges between the pulmonary trunk and the auricle of the left atrium. The cleft through which the finger has passed is the transverse sinus. As the finger lies in the transverse sinus it has in front of it the ascending aorta and the pulmonary trunk, which are enclosed together in a sheath of the serous pericardium, and form the anterior boundary of the transverse sinus. Behind the finger there are the upper parts of the right and left atria, which form the posterior wall of the sinus. Below the finger, at the lower border of the sinus, the serous pericardium is reflected forwards from the front of the atria to the back of the ascending aorta. And above the finger, in the upper wall of the sinus, there is the inferior surface of the right pulmonary artery covered with the serous pericardium as it passes forwards from the upper borders of the atria to the back of the ascending aorta. Fig. 41 represents a sagittal section of a heart in which the transverse sinus is cut across; in it, the various boundaries of the sinus are in apposition with one another, but their relative positions are quite obvious.

Keep a finger in the transverse sinus and introduce a seeker through the cut end of the right pulmonary artery, and pass it to the left until it emerges from the cut end of the left pulmonary artery. Note that, as the instrument traverses the pulmonary arteries, it passes first behind the superior vena cava, and then along the upper wall of the transverse sinus,

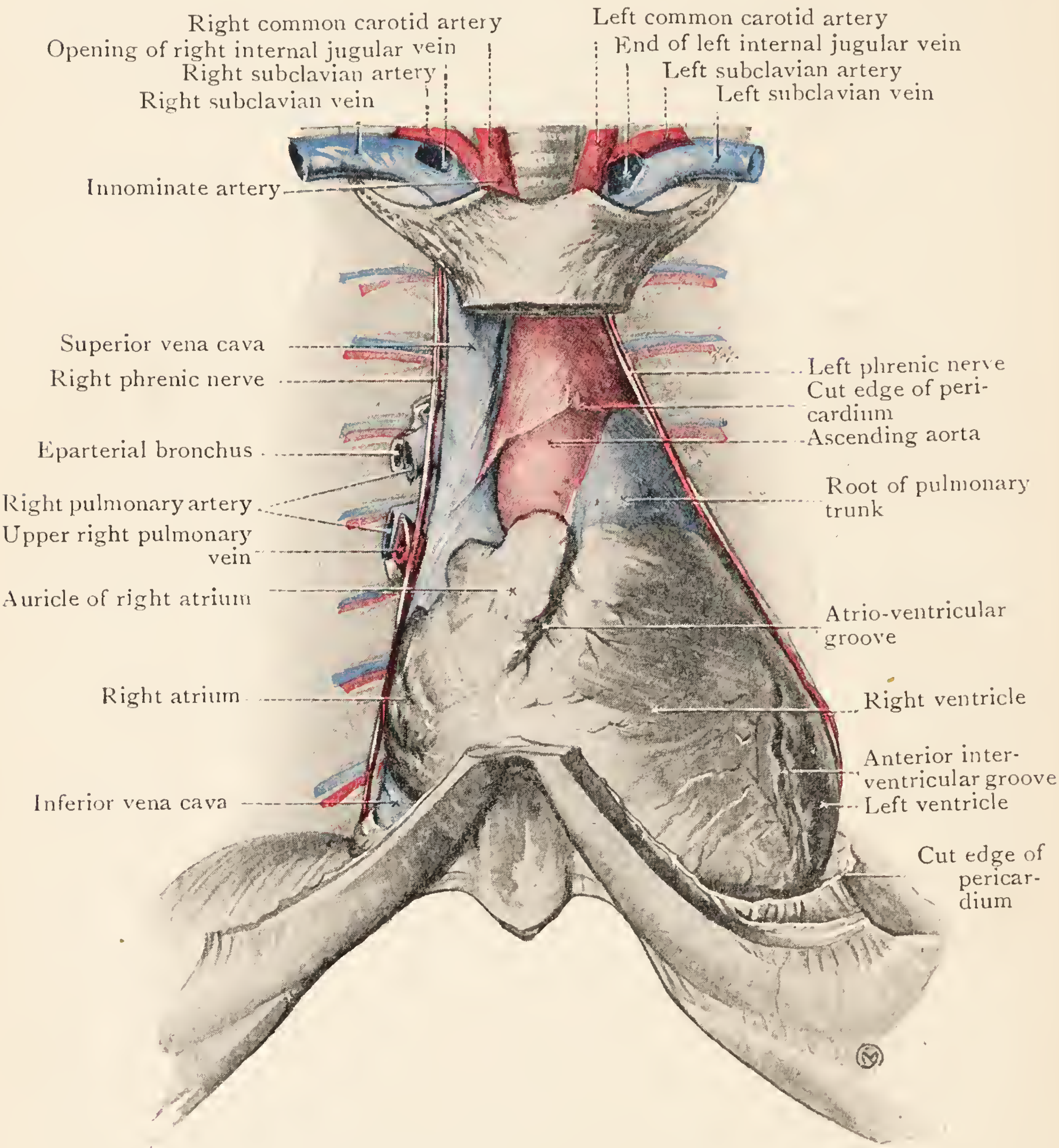


FIG. 39.—Dissection to show Sterno-Costal Surface of Heart *in situ*.

which is parallel with the part of the upper border of the heart formed by the left atrium. Note, further, that the seeker inclines upwards as it passes from right to left, and that the upper border of the heart is therefore correspondingly oblique.

Withdraw the finger, but leave the seeker in position till the surface-anatomy of the heart is studied.

Surface-Anatomy of Heart.—Re-examine the various

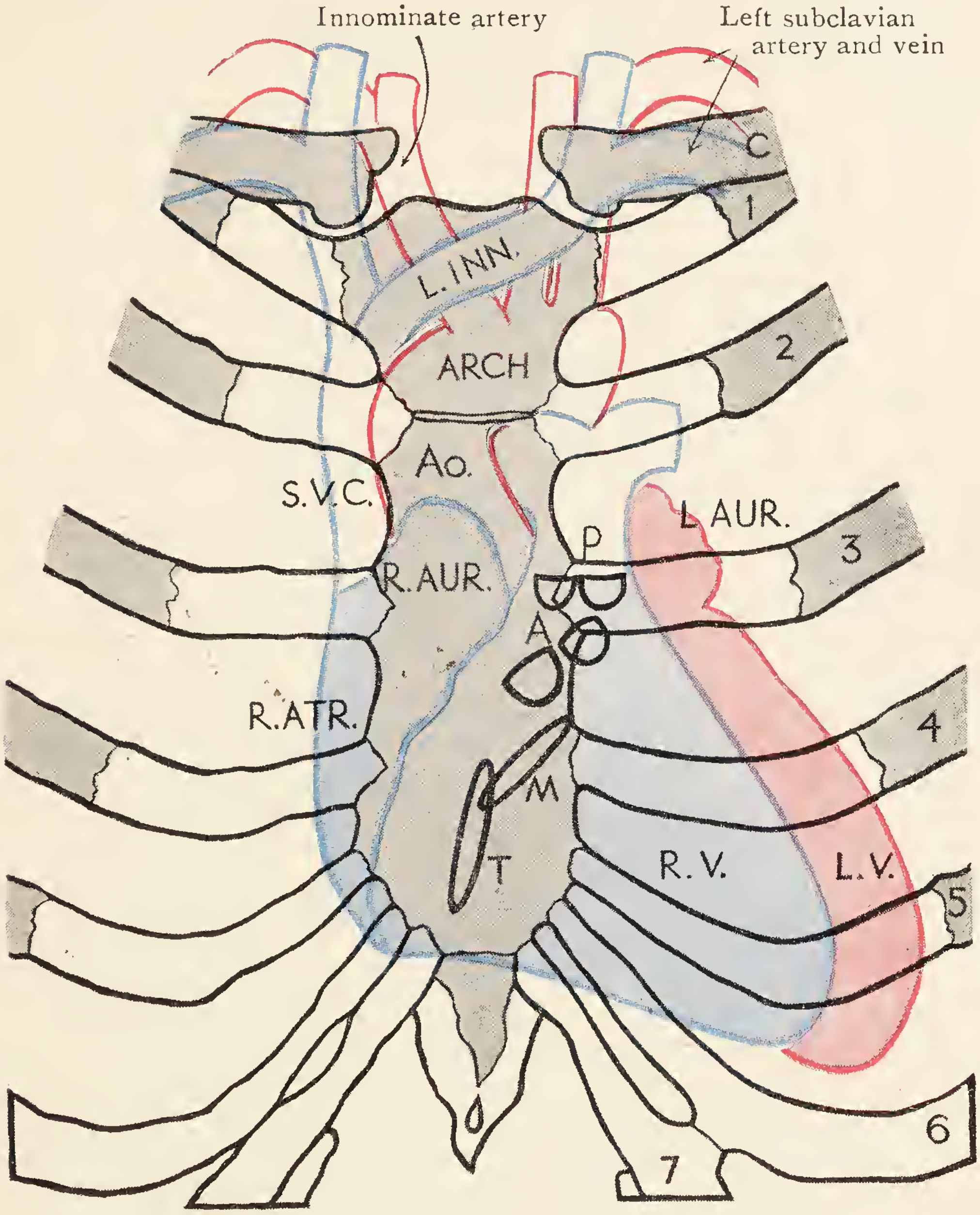


FIG. 40.—Relation of Heart and Great Vessels to Anterior Wall of Thorax.

1 to 7. Ribs and costal cartilages.	M. Mitral orifice.
A. Aortic orifice.	P. Pulmonary orifice.
Ao. Ascending aorta.	R.V. Right ventricle.
C. Clavicle.	S.V.C. Superior vena cava.
L.V. Left ventricle.	T. Tricuspid orifice.

parts of the heart that we have been considering, and note their relation to the anterior wall of the chest. For this purpose, replace the sternum and costal cartilages from time to time.

The *upper border* of the heart is at present concealed to a great extent by the aorta and the pulmonary trunk. Its position is marked on the surface by a line drawn from the lower border of the second left cartilage an inch and a half from the median plane to the upper border of the third right cartilage an inch from the median plane. Since the *pulmonary arteries* run along the upper border of the heart, the right two-thirds of the line will indicate the position of the *right* artery, and the left third the *left* artery. The *right border* is indicated on the surface by a line, slightly convex to the right, drawn from the upper border of the third right costal cartilage an inch from the median plane to the sixth right cartilage half an inch from its junction with the sternum. The *lower border* is slightly concave downwards, in correspondence with the upward convexity of the diaphragm, on which it rests; and it has a slight inclination downwards as it is traced from right to left. It is marked by a line drawn from the sixth right costal cartilage near the sternum to the point opposite the *apex* in the fifth left intercostal space (or on the sixth left cartilage) about three inches from the median plane. The *left border* is marked by a curved line drawn from the point opposite the apex to a point on the lower border of the second left costal cartilage an inch and a half from the median plane.

The *atrio-ventricular groove* can be indicated by a line drawn from the sternal end of the third left costal cartilage to the sternal end of the sixth right cartilage.

The four large orifices of the heart are a little below and to the left of the atrio-ventricular line—namely, the orifices of the pulmonary trunk and aorta, and the openings between left atrium and left ventricle (mitral orifice) and between the right atrium and ventricle (tricuspid orifice). The *pulmonary orifice* is near the left extremity of that line, at the level of the third left costal cartilage. The *aortic orifice* is a little lower and slightly to the right, behind the left margin of the sternum at the level of the third intercostal space. The *mitral orifice* is immediately below the aortic orifice, at the level of the upper part of the fourth left cartilage; and the *tricuspid orifice* is opposite the median line of the sternum, at the level of the fourth intercostal space. The positions of the great orifices cannot be confirmed at this stage, but they will be noted when the heart is opened.

After the dissectors have studied the surface-anatomy of the heart, they should turn the apex upwards and to the right, and examine the inferior and posterior surfaces of the heart while it is still *in situ*.

Diaphragmatic Surface of Heart.—The inferior or *diaphragmatic surface* rests on the diaphragm and is slightly concave; it is formed entirely by the ventricles—mainly by the left ventricle, which forms the left two-thirds. The

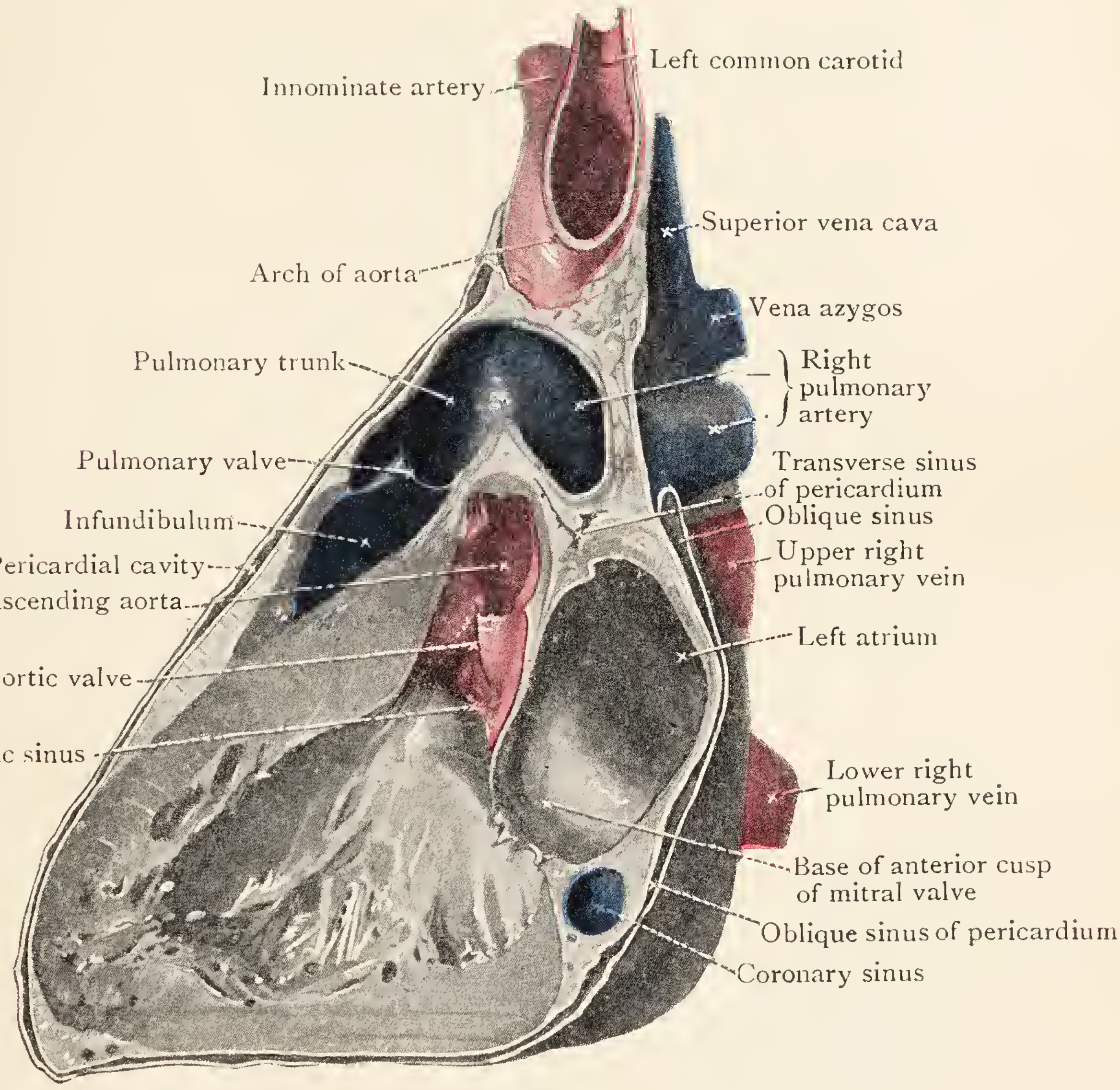


FIG. 41.—Sagittal Section of Heart and Pericardium.

ventricles are separated by the *inferior interventricular groove*, whose position is indicated by longitudinal vessels—the inferior interventricular artery and middle cardiac vein—which may, however, be obscured by a line of fat.

Base of Heart.—A complete examination of the *base* or *posterior surface* of the heart cannot be made until the heart is removed from the thorax at a later stage of the dissection; but pull the apex still farther upwards and to the right, and the lower part of the base will appear to view.

The base is formed by the two atria—chiefly the left atrium—and it is bounded inferiorly by the posterior part of the atrio-ventricular groove. In that groove, the dissectors will see a vein of some width called the *coronary sinus* ; it runs from left to right along the lower border of the base of the heart between the left atrium and left ventricle, and it ends in the right atrium.

Oblique Sinus of Pericardium.—This is the name given to the recess behind the heart, between the left atrium and the pericardium. Pass the fingers into it through its orifice, and feel its boundaries. The orifice looks downwards and to the left, and through it the sinus communicates with the rest of the cavity of the pericardium ; the orifice is bounded to the right and below by the upper end of the inferior vena cava, and to the left and above by the lower left pulmonary vein (Fig. 42). The right and left and upper margins of the sinus are bounded by the reflexion of the serous pericardium from the fibrous pericardium on to the left atrium ; at the upper margin it is reflected directly on to the upper border of the atrium (Fig. 41) ; at the other boundaries it is reflected over the ends of the pulmonary veins on to the right and left borders of the atrium (Figs. 25, 42, 59). The posterior wall of the sinus is the pericardium ; and the pericardium separates the cavity of the sinus from the descending aorta and from the œsophagus, which, in the lower part of this region, is lying between the pericardium and the descending aorta ; both the œsophagus and the aorta can be palpated through the posterior wall of the sinus (Figs. 25, 35). The anterior wall is the back of the left atrium (Fig. 41). Pass the left index finger into the transverse sinus and the middle and index fingers of the right hand into the oblique sinus, and note that the left atrium is the only structure between the two sinuses.

Serous Pericardium.—We come now to a consideration of the relation of the serous pericardium to the heart and the great vessels (see Fig. 42) ; and, to begin with, note that the visceral layer of the serous pericardium covers almost every portion of the heart—the only part left uncovered being the upper border of the left atrium, which is in contact with the right pulmonary artery.

To demonstrate again the lines along which the visceral layer of the serous pericardium becomes continuous with the parietal layer, seize the apex of the heart with the left hand

and lift it upwards, and push the fingers of the right hand backwards over the diaphragmatic surface of the heart and upwards over the back of the left atrium to the upper margin

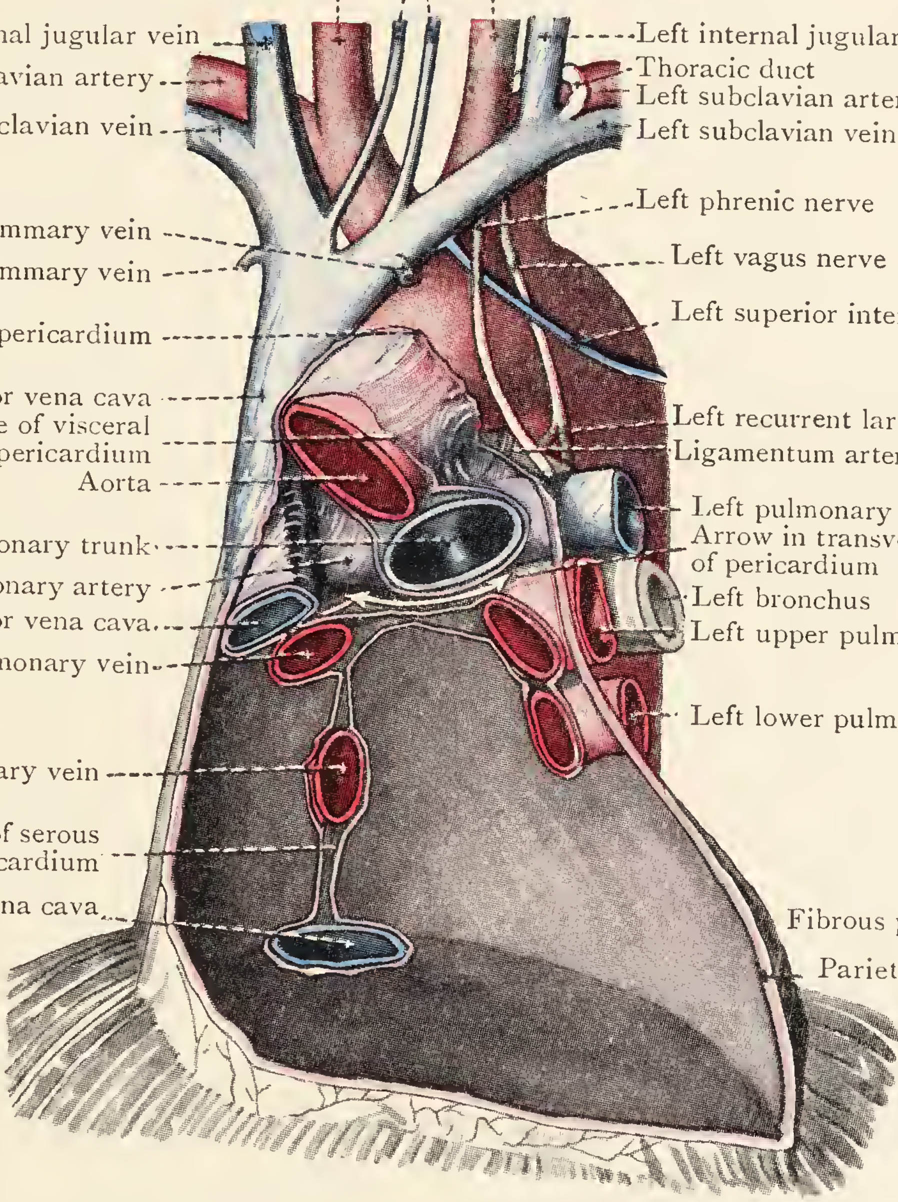


FIG. 42.—Pericardium and Great Vessels.

The organs were hardened *in situ* by formalin-injection. The pericardial cavity was opened by the removal of its anterior wall, the great vessels were divided and the heart was removed. The posterior wall of the oblique sinus is seen between the inferior vena cava and the right pulmonary veins on the right and the left pulmonary veins on the left.

of the oblique sinus. There, the visceral layer passes backwards and joins the parietal layer on the posterior wall of the pericardium. Follow the parietal layer downwards over the posterior wall of the pericardium and forwards over the base or lower wall, and then upwards over the anterior wall (which should be temporarily replaced in position) to its upper border. There, the parietal layer is reflected from the fibrous pericardium on to the aorta and the pulmonary trunk and becomes continuous with the visceral layer again ; and the fingers, tracing the visceral layer, will pass downwards over the two great arteries and the ventricles to the lower border of the sterno-costal surface—so completing the circuit of the heart in the sagittal plane, and demonstrating that it is covered on the posterior, inferior and anterior surfaces by the serous layer of the pericardium.

Note that the serous pericardium which surrounds the cavity of the transverse sinus covers the back of the aorta and pulmonary trunk, and that it passes backwards from them across the lower surface of the right pulmonary artery and then downwards over the front of the left atrium. Behind the latter reflexion, the upper border of the atrium is not covered with serous pericardium—in the angle between the transverse sinus and the upper end of the oblique sinus. (See Fig. 41 ; and also Fig. 59, in which the prolongation upwards of the fibrous pericardium on to the back of the right pulmonary artery has been removed.) The fact that a finger can be passed through the transverse sinus behind the aorta and the pulmonary trunk, but that it cannot be insinuated between the two vessels, will indicate that the two great arteries are enclosed in a single sheath of serous pericardium.

An examination of the venæ cavæ will show that the lower inch of the superior vena cava lies within the fibrous pericardium and that the serous pericardium ensheaths it, except along its postero-medial border, whilst the inferior vena cava can scarcely be said to have any intrapericardial course, for it joins the lower and posterior part of the right atrium immediately after it pierces the fibrous pericardium ; but the margin of the orifice by which it enters is surrounded by the reflexion of the serous pericardium except along a narrow line posteriorly (Fig. 42). The left pulmonary veins are covered with the serous pericardium above, in front and below, but not posteriorly. The right pulmonary veins enter the left atrium as soon as they have pierced the fibrous pericardium, and are therefore in relation with the serous layer merely along the borders of the orifices through which they enter the pericardium (Fig. 42).

Vessels and Nerves of Heart.—The vessels and nerves which supply the walls of the heart should now be studied. They are the coronary arteries and the cardiac veins and nerves ; and the main stems of the vessels lie in the atrio-ventricular and interventricular grooves of the heart, usually embedded in fat.

Dissection.—Cut the epicardium that overlies the vessels ; turn it aside, and remove the fat. Clean the main vessels and their branches—trying, at the same time, to preserve the nerves that accompany them.

Coronary Arteries.—The coronary arteries are the nutrient vessels of the heart, and are greatly enlarged *vasa vasorum*. They spring from dilatations of the root of the aorta which are called the *sinuses of the aorta*. There are three of these sinuses (an anterior and two posterior) and only two coronary arteries (a right and a left) ; the right artery springs from the anterior sinus, and the left from the left posterior sinus (Figs. 26, 43, 54). Their orifices are immediately above the level of the cusps of the aortic valve—as will be seen when that valve is examined (p. 105).

The **right coronary artery** passes forwards between the pulmonary trunk and the auricle of the right atrium, and runs downwards, in the atrio-ventricular groove, to the lower part of the right margin of the heart, round which it curves. It then proceeds to the left, in the posterior part of the atrio-ventricular groove, and ends by anastomosing with the left coronary artery. During its course, it gives branches to the roots of the aorta and pulmonary trunk and to the walls of the right atrium and ventricle. The most constant of these are : (1) a slender *marginal artery*, which runs from right to left along the lower margin of the front of the heart ; and (2) an *interventricular branch*, which runs forwards on the diaphragmatic surface.

The **left coronary artery** runs for a short distance towards the left behind the pulmonary trunk, and then forwards to appear between the pulmonary trunk and the auricle of the left atrium (Fig. 26) ; it next curves backwards and downwards in the left part of the atrio-ventricular groove to reach the lower border of the base of the heart, where it ends by anastomosing with the right coronary.

Its branches supply the roots of the aorta and pulmonary trunk and the walls of the left atrium and ventricle. By far the largest branch is the interventricular. The *interventricular branch* is larger than the continuation of the parent stem. It arises at the point where the stem appears between the pulmonary trunk and the auricle; and it runs in the anterior interventricular groove towards the apex, giving branches to both ventricles.

The two coronary arteries are the only arteries that supply

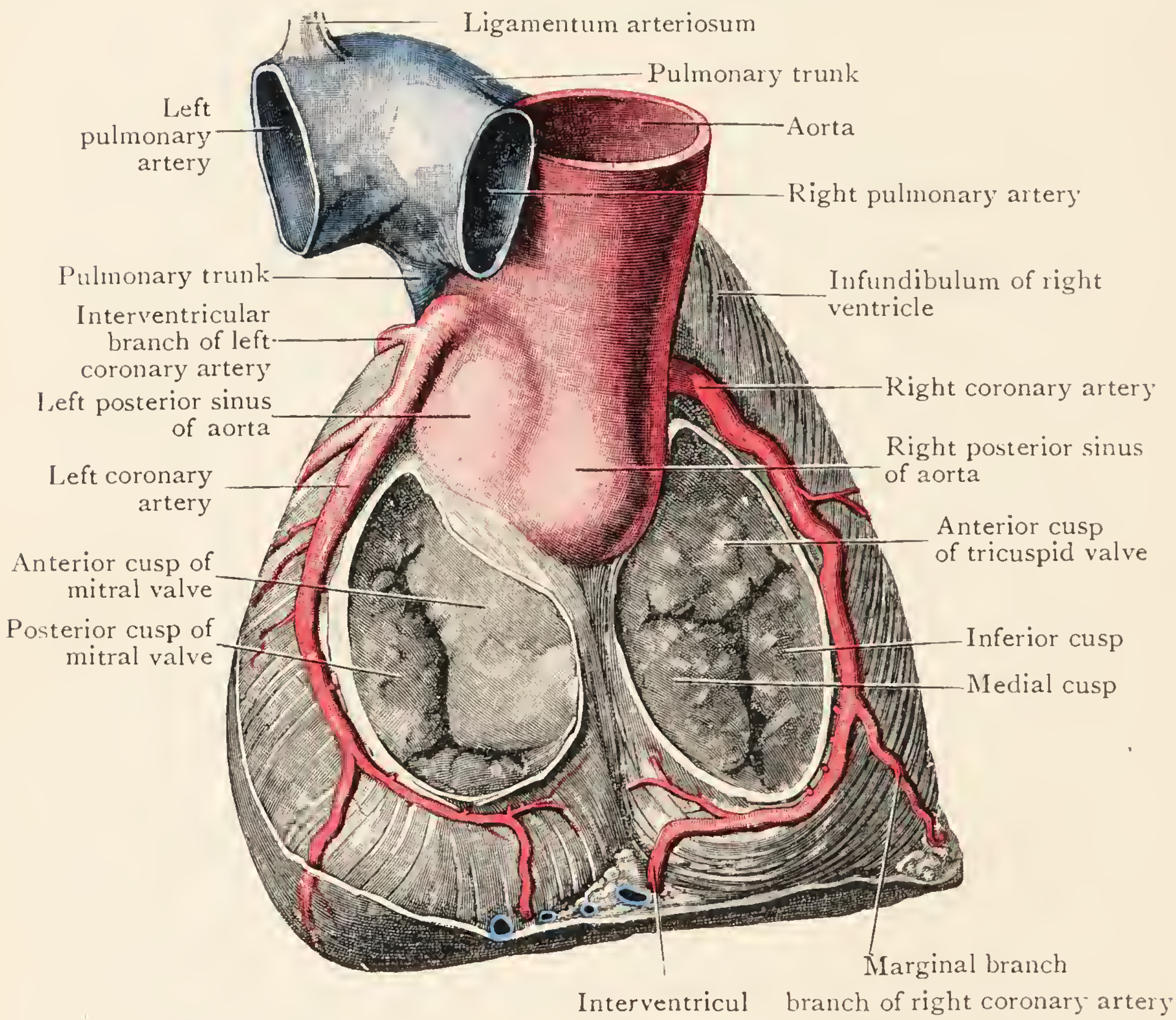


FIG. 43.—Base of Ventricular Part of a Heart (hardened *in situ*) from which the Atria have been removed. The detached atria are depicted in Fig. 45. The right-hand side of the Figure is the sterno-costal surface.

the walls of the heart, and they form no effective anastomoses with any other arteries. For this reason, the blood supply to the walls of the heart is stopped if they are obliterated, and death must ensue.

Veins of Heart.—A little of the venous blood in the walls of the heart is collected by very small veins called the *venæ cordis minimæ*, which lie in the substance of the walls and open directly into the chambers—chiefly into the right atrium. But most of the blood is collected by veins that form networks on the surface of the heart. These networks are drained by the *anterior cardiac veins* and the tributaries of the *coronary sinus*. The named tributaries of the sinus are the *great cardiac vein*, the *small cardiac*, the *middle cardiac* and the *oblique vein of the left atrium* (Fig. 44).

The **anterior cardiac veins** are small vessels which course over the anterior surface of the right ventricle and atrium, and enter the right atrium near the atrio-ventricular groove.

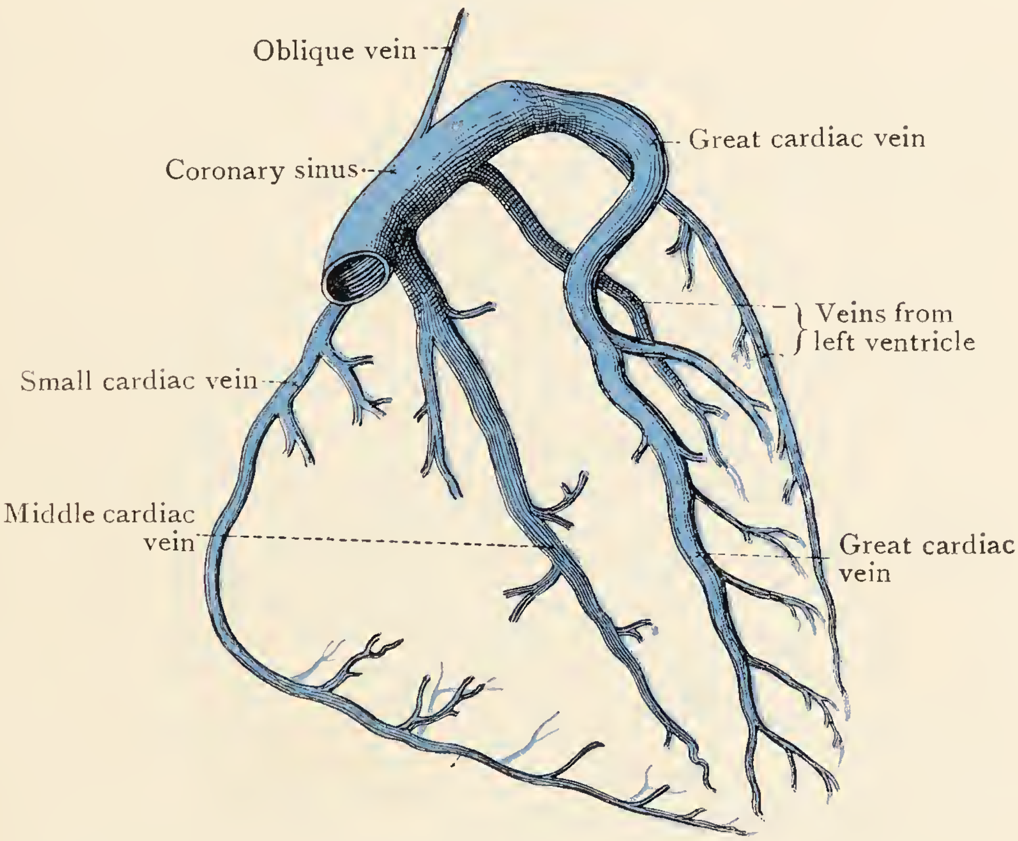


FIG. 44.—Diagram of Veins on the Surface of Heart.

The **coronary sinus** runs from left to right along the lower border of the base of the heart, in the posterior part of the atrio-ventricular groove, between the left atrium and the left ventricle. It was displayed when the apex of the heart was turned upwards and to the right (p. 76). Its right extremity opens into the right atrium immediately to the left of the orifice of the inferior vena cava (Figs. 46, 48). At its left extremity it receives the great cardiac vein.

The *great cardiac vein* ascends in the anterior interventricular groove (Fig. 38), alongside the interventricular branch of the left coronary artery. At the upper end of the groove, it turns to the left and then runs backwards and downwards in the left part of the atrio-ventricular groove, with the left coronary artery; and it ends in the left extremity of the coronary sinus. The *small cardiac vein* runs from left to right along the lower margin of the heart, curves round the right border of the heart, in the atrio-ventricular groove, and ends in the coronary sinus near its termination. The *middle cardiac vein* runs backwards in the inferior interventricular

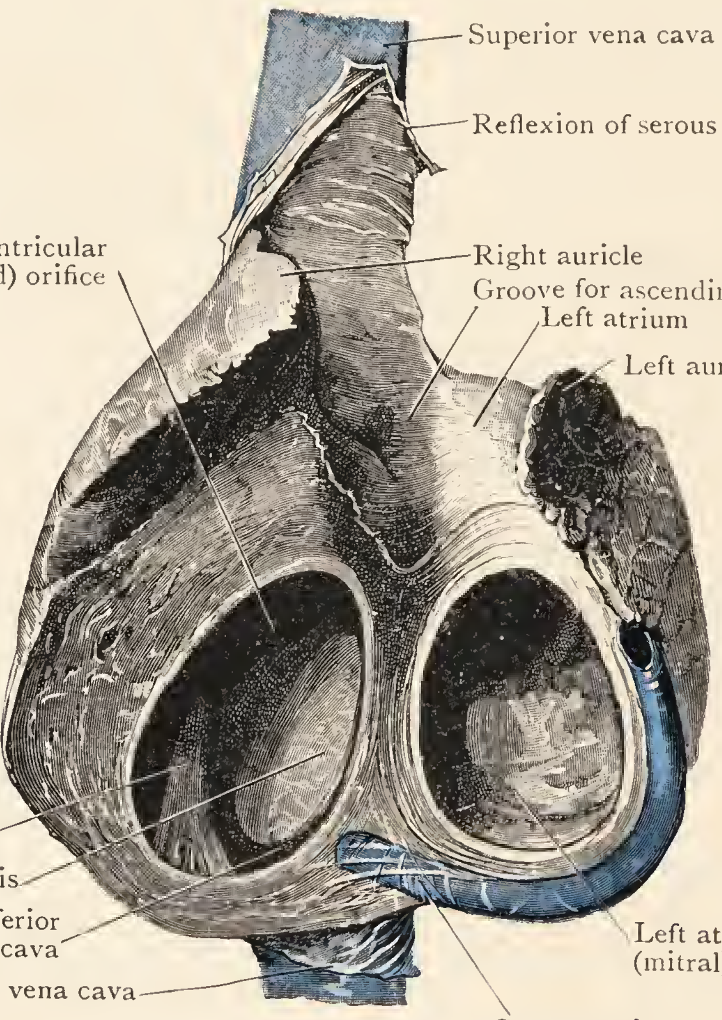


FIG. 45.—Anterior aspect of Atrial Part of a Heart from which the ventricles have been removed. The detached ventricles are depicted in Fig. 43. The whole specimen had been hardened *in situ*.

groove and also ends in the coronary sinus near its termination.

The *oblique vein* is a very slender vessel that descends over the posterior wall of the left atrium and ends in the coronary sinus about its middle (Figs. 44, 59). It is of developmental interest because it represents the terminal part of a left superior vena cava that existed in early fœtal life.

A valve is placed at the junction of the great cardiac vein and the coronary sinus ; and the orifice of the small cardiac vein may be provided with a valve ; but the orifices of the other tributaries of the sinus are generally devoid of valves.

Nerves of Heart.—The nerves that enter the substance of the heart are derived directly from the coronary plexuses, which are offshoots of the superficial and deep cardiac plexuses (pp. 58, 118), and they descend along the pulmonary trunk to the heart.

The *right coronary plexus* is formed by filaments from both cardiac plexuses, and is distributed along the course of the right coronary artery. The *left coronary plexus* accompanies the artery of the same name, and is derived from the deep cardiac plexus. The nerves do not slavishly follow the arteries ; they soon leave the vessels, and are ultimately lost in the substance of the heart. Here and there, ganglia are developed in connexion with them.

CHAMBERS OF HEART.—The atria and the ventricles, and also the great vessels which communicate with them, should now be examined as far as possible while the heart is still *in situ*, in order that the relations of the orifices to the sternum and costal cartilages may be seen. Examine first the right atrium and the venæ cavæ, then the right ventricle and the pulmonary trunk, and afterwards the left ventricle and the ascending aorta. Replace the sternum and costal cartilages from time to time, note the relation of the parts of the heart to the surface (Fig. 40), and compare what is found with the average relationships described on pp. 73, 74.

The examination of the left atrium and of the termination of the pulmonary veins cannot be conveniently undertaken until the heart and the pericardium have been removed from the body (see p. 106).

Dissection.—Open the *right atrium* by the following incision. Enter the knife at the apex of the auricle and carry it backwards, close to the upper border of the auricle, and through the lateral wall of the atrium to the posterior border of the lower end of the superior vena cava ; then downwards to the inferior vena cava ; and, finally, forwards above the front of the upper end of the inferior vena cava to the atrio-ventricular groove.

Throw the flap thus formed forwards, and clean the interior of the cavity with a sponge.

Right Atrium.—As the flap formed by the anterior and lateral walls of the right atrium is turned forwards, a vertical ridge will be noted on its inner surface. It is named the *crista terminalis*, and extends from the front of the orifice of the superior vena cava to the front of the orifice of the inferior vena cava ; it corresponds in position with an indistinct vertical groove—the *sulcus terminalis*—on the outer surface. It marks the boundary between an anterior part of the atrium,

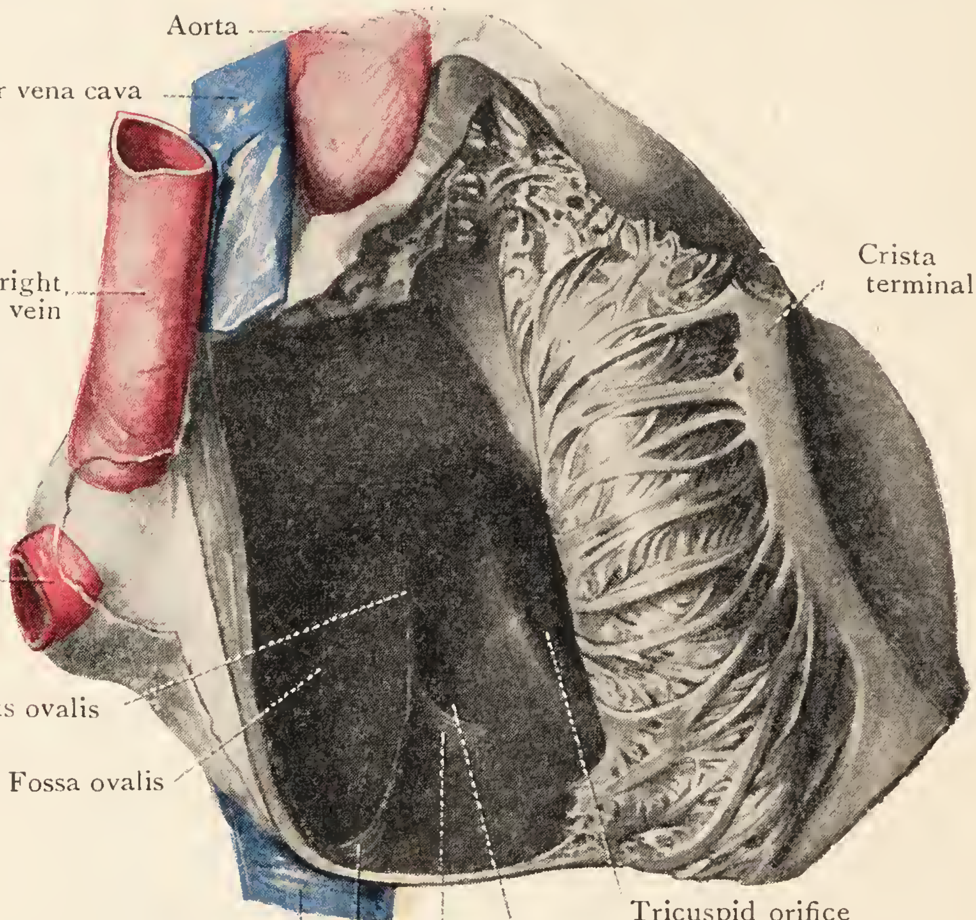


FIG. 46.—Right Atrium. Part of the posterior wall and the whole of the right lateral and anterior walls have been turned forwards.

from which the auricle springs, and a posterior part, which forms a *venous sinus* into which the venæ cavæ and the coronary sinus open (Figs. 46, 47). The two parts of the cavity differ not only in position and in their relations to the great veins, but also in the character of their walls. The whole of the interior of the atrium presents a polished, glossy appearance, due to the endocardial lining ; but, whilst the wall of the venous sinus is smooth, the rest of the wall of the atrium is rugose, owing to a large number of muscular ridges which begin at the crista terminalis and run forwards to the right margin of the atrium and into the auricle. The muscular ridges, on account of their resemblance to the teeth of a comb, are called the *musculi pectinati*.

The veins which open into the right atrium are :—(1) superior vena cava, (2) inferior vena cava, (3) coronary sinus, (4) anterior cardiac veins, and (5) venæ cordis minimæ.

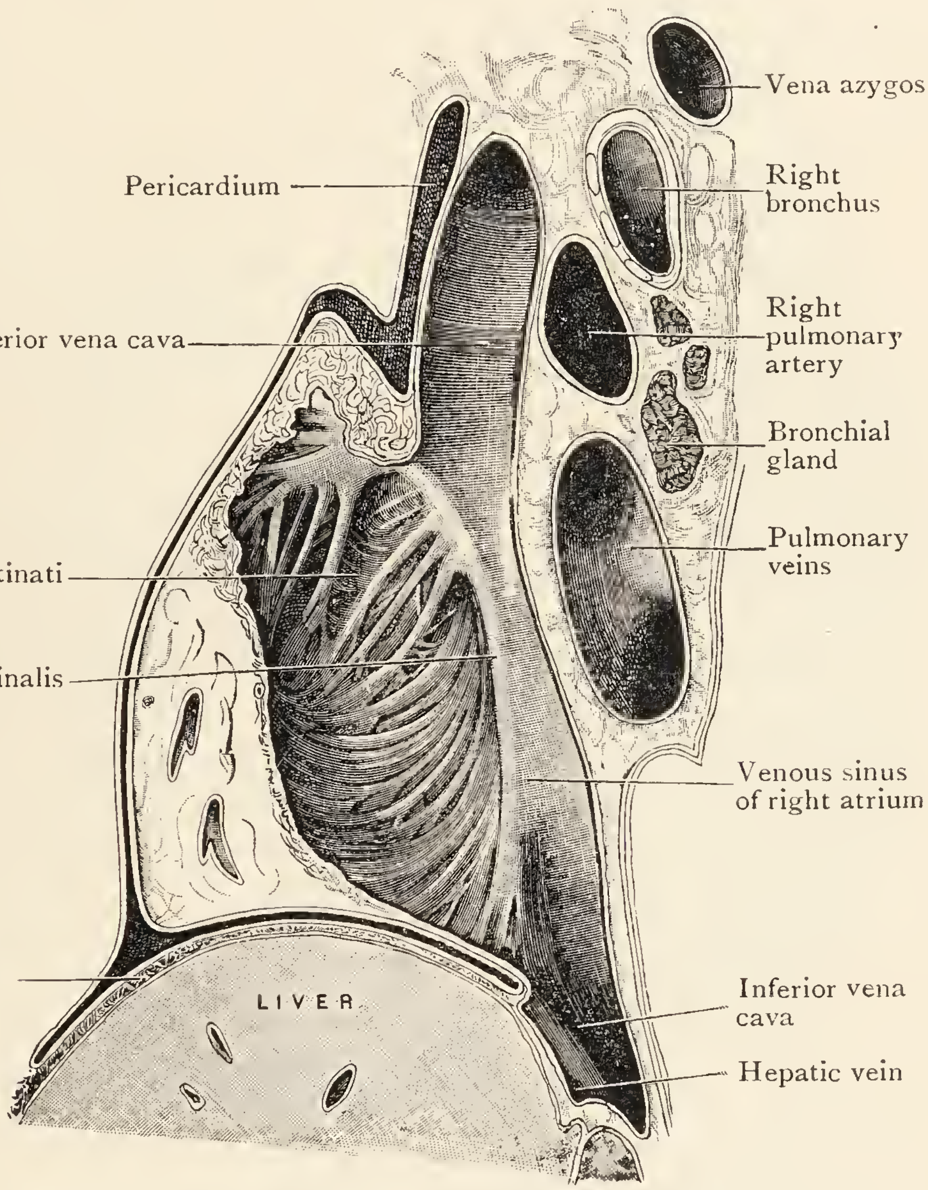


FIG. 47.—Sagittal Section through Right Atrium of Heart and Root of Right Lung.

The aperture by which the blood leaves the atrium is the right atrio-ventricular or tricuspid orifice.

Orifices of Right Atrium.—The *orifice of the superior vena cava* is in the upper and posterior part of the atrium, at the level of the third right costal cartilage close to its junction with the sternum. It is entirely devoid of any valvular arrangement.

The *orifice of the inferior vena cava* is in the lower and posterior part of the atrium, at the level of the sixth right costal cartilage close to the sternum. A thin ridge or fold of endocardium—a remnant of the *valve of the inferior vena cava* of the foetus—runs from right to left along the anterior margin of the orifice, between the orifice and the atrio-ventricular opening (Figs. 46, 48). The left end of the ridge is continuous with the lower end of a curved ridge, called the *annulus ovalis*, which lies on the atrial septum and forms the anterior and upper boundary of a wide, shallow depression called the *fossa ovalis* (Figs. 46, 48). At the upper end of the fossa ovalis there was, during fœtal life, an aperture called the *foramen ovale*, through which the two atria communicated with each other. The valve of the vena cava was much more perfect in fœtal life, and its object was to direct the inferior caval blood through the foramen ovale into the left atrium, whence it was passed into the left ventricle, and was then distributed by the aorta throughout the whole body.

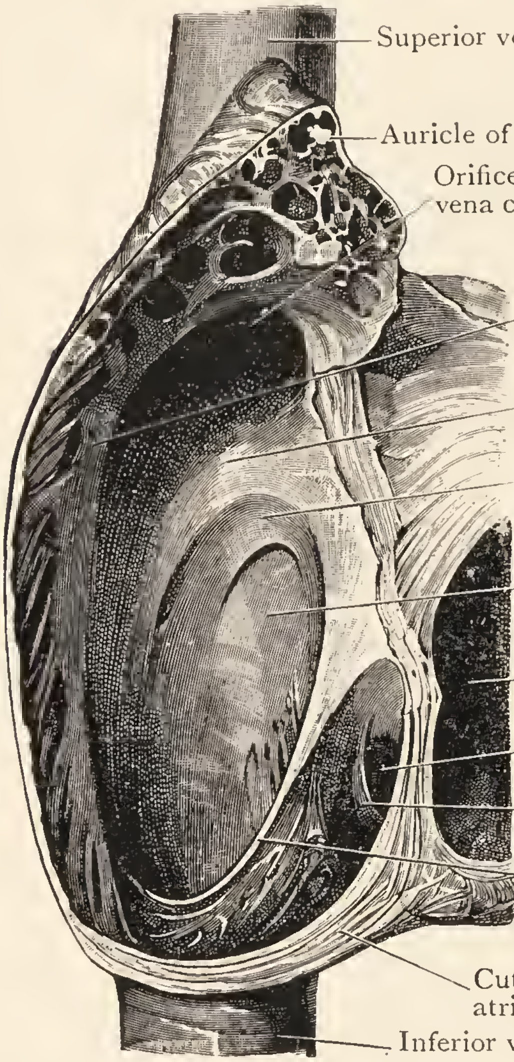


Fig. 48.—Interior of Right Atrium as seen after the removal of the anterior wall, which is opposed to the base of the Ventricle. This is a part of the same specimen that is depicted in Figs. 43, 45.

A small part of the foramen ovale often persists in the adult. If it is present, it will be found under cover of the upper part of the annulus ovalis, and a probe should be passed through it into the left atrium.

The *opening of the coronary sinus* is to the left of the lower end of the annulus ovalis and directly behind the tricuspid orifice (Figs. 46, 48). On its right margin there is a valvular fold—*the valve of the coronary sinus*—which turns the blood of the sinus forwards into the atrio-ventricular orifice.

The venæ cordis minimæ open into the atrium by small orifices scattered irregularly over the walls; and the anterior cardiac veins pierce its anterior wall.

The *right atrio-ventricular* or *tricuspid orifice* is in the

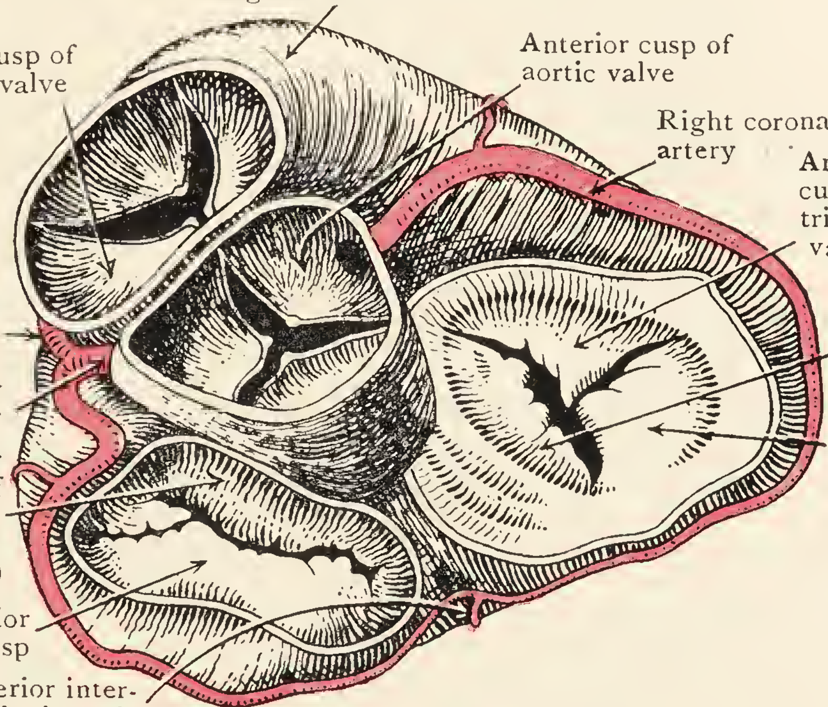


FIG. 49.—Base of Ventricular Part of a Heart, showing atrio-ventricular and arterial orifices with their valves, and the coronary arteries. Anterior surface of heart is above and towards the right in the Figure.

lower and anterior part of the atrium. It opens into the lower and posterior part of the right ventricle, and it is sufficiently large to admit the tips of three fingers. It is bounded by a fibrous ring to which the cusps of the right atrio-ventricular valve are attached. These cusps will be examined when the right ventricle is opened.

Atrial Septum and Fossa Ovalis.—The *atrial septum* is a fibro-muscular partition which intervenes between the right and left atria (Fig. 56). In the fœtus it is incomplete, owing to the presence of an obliquely directed foramen—the *foramen ovale*—already referred to; and in the adult it is marked on the lower and posterior part of its right side by the *fossa ovalis*. The fossa is bounded anteriorly and above by the *annulus ovalis*, whilst below and posteriorly it fades away into the orifice of the inferior vena cava. The floor of the fossa is thin; it marks the situation of the lower part of the boundary of the foramen ovale of the fœtus, and is formed by a portion of the interatrial wall which, in the fœtus, acted as a flap-valve and prevented regurgitation of blood from the left atrium into the right.

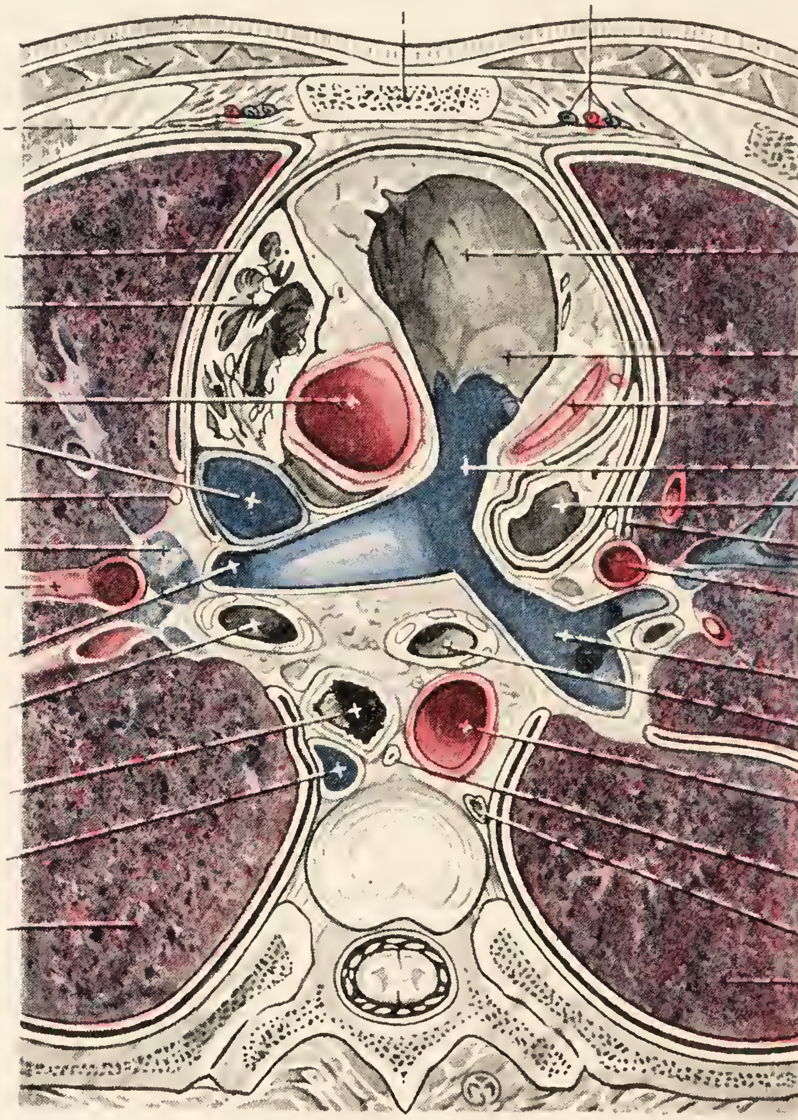


FIG. 50.—Transverse Section through Thorax along the line **C-C**, Fig. 19. Seen from below. The counterpart—the upper surface of the next section—is seen in Fig. 26, p. 47.

Vena Cava Superior.—The superior vena cava collects the venous blood from the head and neck, the upper limbs, the walls of the thorax, and the upper parts of the walls of the abdomen, and carries it to the right atrium. It begins, by the union of the right and left innominate veins, at the level of the lower border of the sternal end of the first right costal cartilage (Fig. 40); and it ends in the upper and posterior part of the right atrium, at the level of the third right costal cartilage, opposite the right border of the sternum. Its upper half lies in the superior mediastinum; its lower half lies in the middle mediastinum, enclosed within the fibrous pericardium and partly ensheathed by the serous pericardium (Fig. 42).

Tributaries.—The tributaries of the superior vena cava are the two innominate veins, by whose junction it is formed, and the vena azygos, which enters the back of it immediately before it pierces the fibrous pericardium, at the level of the second right costal cartilage (Fig. 19).

Relations (Figs. 28, 50, 58).—The *upper half* is above the pericardium and is related to structures in the superior mediastinum :—The trachea is medial to it and behind it; the end of the ascending aorta is medial and in front; the right pleura and lung are lateral to it and overlap it in front and behind; the phrenic nerve and pericardiaco-phrenic vessels are lateral to it, between it and the pleura; and the vena azygos enters the back of it immediately above the pericardium.

The *lower half* is related, within the pericardium, to the ascending aorta, which is medial and in front, and to the auricle of the left atrium, which is in front of the lower end of the vena cava (Fig. 47). The structures outside the pericardium which are related to it are the upper half of the root of the right lung behind, the right pleura and lung laterally and in front, and the phrenic nerve (with the accompanying vessels) laterally, between the pleura and the pericardium.

Vena Cava Inferior.—Only a small portion—about three-quarters of an inch—of the inferior vena cava is found in the thorax. It ascends from the diaphragm along the mediastinal surface of the right pleura and lung, pierces the pericardium in front of the lower border of the right pulmonary ligament, and ends at once in the lower and posterior part of the right atrium (Figs. 17, 19, 59).

Relations (Fig. 15).—The diaphragm is in front of it; the vena azygos and the greater splanchnic nerve are behind it; the phrenic nerve is lateral to it; so are the right pleura and lung, and they are also behind it.

Dissection.—Open the cavity of the right ventricle by three incisions. Make the first transversely across the infundibulum immediately below the pulmonary trunk; begin a little to the right of the upper end of the anterior interventricular groove and end a little to the left of the atrio-ventricular groove. Begin the second at the right end of the first, and pass obliquely downwards and to the right, along the left margin of the atrio-ventricular groove, to the inferior border of the heart. The third begins at the left end of the first, follows the line of the anterior interventricular groove—a little to its right side—and also ends at the lower margin of the heart.

Turn the triangular flap thus formed downwards and to the right, and clean the cavity of the ventricle with the sponge and forceps. If a muscular bundle, called the *moderator band*, which connects the anterior wall of the ventricle with the ventricular septum, interferes with the necessary displacement of the flap, it must be divided.

Right Ventricle.—The cavity of the right ventricle has a triangular outline. The atrio-ventricular orifice is at the lower and posterior angle; and the pulmonary trunk springs from the upper and posterior angle. The portion below the pulmonary orifice, being funnel-shaped, is called the *infundibulum*; and, between the two orifices, a thick, rounded ridge, called the *infundibulo-ventricular crest*, bulges into the cavity.

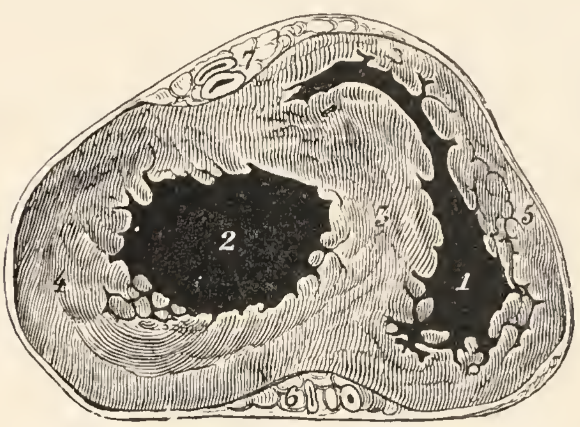


FIG. 51.—Transverse Section through Ventricular Part of Heart (Luschka). Seen from above.

1. Cavity of right ventricle.
2. Cavity of left ventricle.
3. Ventricular septum.
4. Thick wall of left ventricle.
5. Thinner wall of right ventricle.
6. Inferior interventricular groove with middle cardiac vein and interventricular branch of right coronary artery.
7. Anterior interventricular groove with great cardiac vein and interventricular branch of left coronary artery.

On transverse section the cavity of the right ventricle is semilunar in outline, because the ventricular septum, which forms the left and posterior wall, is convex towards the right ventricle (Fig. 51). Its walls are much thicker than the walls of the right atrium, but much thinner than the walls of the left ventricle (Fig. 51). The reason for the difference is obvious: the atrium has merely to complete the discharge of the blood through the tricuspid orifice into the right ventricle, and the right ventricle has only to send the blood through the lungs to the left atrium; but the left ventricle has to force the blood through the whole body; and the muscular strength of the walls of the cavities of the heart is proportional to the work they have to do.

The *infundibulum* (conus arteriosus) is the uppermost part of the right ventricle, and its walls are smooth and devoid of projecting muscular bundles (Fig. 52). The inner surface of the walls of the remaining part of the ventricle is extremely irregular owing to a lace-work of fleshy ridges called *trabeculæ carneæ* (Figs. 52, 54). Some of the trabeculæ are merely ridges raised in relief on the surface; others are attached to the wall at each extremity but are free in the rest of their extent. The cavity of the ventricle is invaded not only by the trabeculæ carneæ but also by a number of conical muscular projections called the *papillary muscles*. They are attached by their bases to the wall of the ventricle, and their apices are connected by a number of tendinous strands called *chordæ tendineæ* to the cusps of the tricuspid valve. As a rule, there is a large *inferior papillary muscle* attached to the lower wall, a larger *anterior papillary muscle* attached to the anterior wall, and a number of small *septal papillary muscles* attached to the septum. Occasionally the anterior and inferior muscles are divided into a number of smaller projections.

Note that the chordæ tendineæ gain insertion into the margins and ventricular surfaces of the cusps of the valve, and that each group of chordæ is distributed to the adjoining halves of two cusps. Since the papillary muscles contract at the same time as the walls of the ventricle, the result of this distribution of the chordæ tendineæ is that they hold the margins of the cusps together and at the same time prevent them being driven backwards into the atrium.

One of the trabeculæ carneæ, which is usually strong and well-marked, passes across the cavity from the septum to the base of the anterior papillary muscle. It is called the *moderator band*. It tends to prevent over-distension of the cavity of the ventricle by fixing the more yielding anterior wall of the ventricle to the more solid septum; and it forms a pathway for the right branch of the atrio-ventricular bundle (Figs. 60, 61), which will be dissected later.

Orifices of Right Ventricle and their Valves.—There is one opening of entrance into the right ventricle—the right atrio-ventricular; and one opening of exit—the pulmonary orifice. Each is guarded by a valve.

Right Atrio-Ventricular Orifice.—This opening is at the lower and posterior part of the right ventricle. It is about one inch in diameter, and is surrounded by a fibrous ring. It admits the tips of three fingers, and it is guarded by a valve

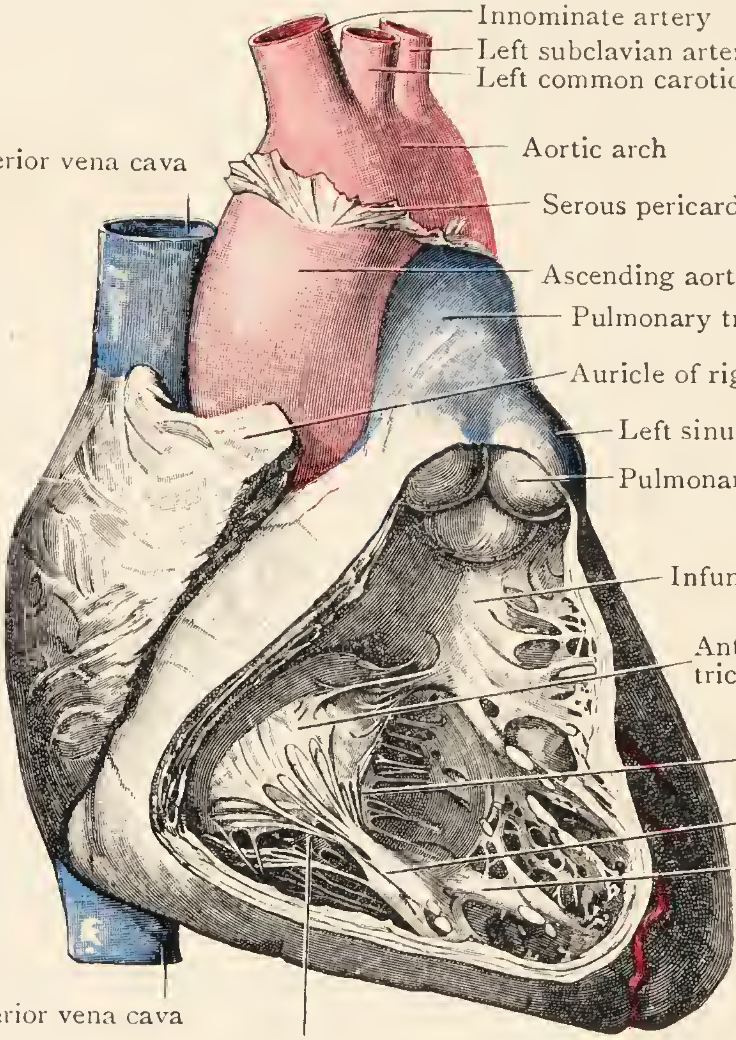


FIG. 52.—Interior of Right Ventricle.

which possesses three cusps and is called therefore the *tricuspid valve.*

Tricuspid Valve.—The three cusps of the right atrio-ventricular or tricuspid valve occupy definite positions: one is *anterior*, another *medial*, and the third *inferior*. The anterior cusp intervenes between the atrio-ventricular orifice and the infundibulum; the medial cusp lies in relation with the septal wall of the ventricle and the inferior cusp with the inferior wall. Occasionally small additional cusps are interposed between the three main cusps.

The bases of the cusps are attached to the fibrous ring around the orifice. Their apices, margins and ventricular surfaces give attachment to the chordæ tendineæ. Their atrial surfaces, over which blood flows as it enters the ventricle, are smooth, and their ventricular surfaces are roughened by the attachment of the chordæ tendineæ.

Pulmonary Orifice.—The pulmonary orifice is in the upper, posterior, and left part of the ventricle, at the apex of the infundibulum. It is surrounded by a thin fibrous ring to which the bases of the three cusps of the pulmonary valve are attached. The root of the pulmonary trunk shows a slight bulging immediately above each cusp—one posterior and two anterior.

Dissection.—Make a transverse incision across the anterior wall of the pulmonary trunk immediately above the bulgings, and from each end of it make a vertical incision upwards towards the arch of the aorta ; raise the flap so formed and examine the cusps of the valve from above.

Pulmonary Valve.—Each cusp of the valve is of semilunar form. Its upper or arterial surface is concave, its lower or ventricular surface is convex ; and it consists of a layer of fibrous tissue covered, on each surface, with a layer of endothelium. The fibrous basis of the cusp is not equally thick in all parts. A stronger band runs round both the free and the attached margin. The centre of the free margin is thickened to form a small, rounded mass—the *nodule of the valve*—and the small, thin crescentic regions on each side of the nodule are called the *lunules of the valve.* When the ventricular contraction ceases, and the elastic reaction of the wall of the pulmonary trunk forces the blood backwards towards the ventricle, the cusps of the valve are forced into apposition ; the nodules meet in the centre of the lumen ; the ventricular surfaces of the lunules of adjacent cusps are compressed against each other, and their free margins project upwards into the cavity of the artery in the form of three ridges which radiate from the nodules to the wall of the artery. Regurgitation of blood into the ventricle is thus prevented.

The dissectors may readily demonstrate the general appearance of the cusps and their relationship to each other by packing the concavity of each cusp with cotton wool.

Pulmonary Trunk.—The pulmonary trunk is about two inches long and nearly one inch in diameter. It lies within the fibrous pericardium, enclosed, with the ascending aorta, in a sheath of the serous pericardium. It begins at the upper end of the infundibulum, behind the sternal extremity of the third left costal cartilage ; and it runs backwards and upwards into the concavity of the aortic arch, where it bifurcates to form the right and left pulmonary arteries. The bifurcation takes place opposite the sternal end of the second left costal cartilage.

Relations.—At first it is placed in front of the ascending aorta, but as it runs backwards and upwards it passes to the left side of the aorta, and lies in front of the upper part of the left atrium, from which it is separated by the transverse sinus of the pericardium. Anteriorly, the pericardium separates it from the anterior part of the left pleura and lung. On its right side the right coronary artery and the apex of the auricle of the right atrium are related to its lower part, and the ascending aorta to its upper part. Its left side is related to the left coronary artery and the auricle of the left atrium.

The **right pulmonary artery** commences below the arch of the aorta, and runs to the right and slightly downwards to reach the hilum of the right lung (Figs. 35, 41, 59). In its course, it passes along the upper border of the heart and the transverse sinus of the pericardium, behind the ascending aorta and the superior vena cava, and in front of the œsophagus and the stem of the right bronchus. Near the lung it gives off a large branch which accompanies the eparterial bronchus.

The **left pulmonary artery** runs to the left and backwards, across the front of the descending aorta and the left bronchus, to the hilum of the left lung. It lies behind the upper and left part of the pericardial sac, which separates it from the posterior part of the auricle of the left atrium (Fig. 50).

The arrangement of the pulmonary arteries and their branches inside the lungs is described on p. 55.

Ligamentum Arteriosum.—This ligament has been exposed already (p. 57). It is a short and fairly strong fibrous band that connects the root of the left pulmonary artery with the lower surface of the arch of the aorta.

The left recurrent laryngeal nerve curves round the lower surface of the aortic arch immediately behind the upper end of the ligamentum arteriosum, and the superficial cardiac plexus lies below the aortic arch in front of the ligament and slightly to the right of it.

In the adult, the ligament has no particular importance, and its interest lies in the fact that it is the remains of the walls of a wide channel, called the *ductus arteriosus* (Fig. 53), which united the pulmonary trunk of the fœtus with the aorta.

During fœtal life the lungs had no aerating function ; the pulmonary arteries were therefore small. At that period, the blood which had entered the right ventricle was ejected by the ventricle into the pulmonary trunk, and the greater part of it passed through the ductus arteriosus into the aorta, which it entered beyond the origin of the left subclavian artery. There, it mingled with the blood from the placenta, the lower part of the trunk, and the lower limbs ; that blood had passed from the

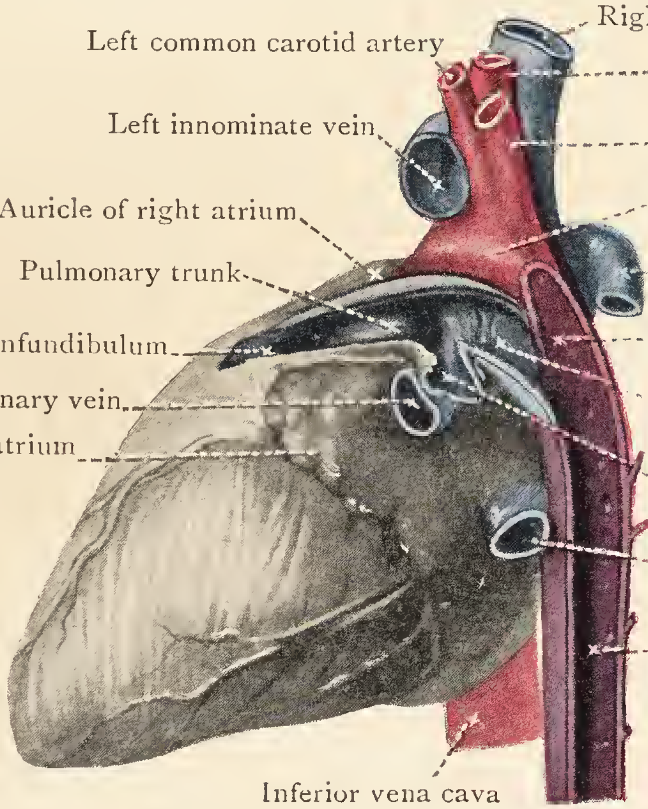


FIG. 53.—Dissection of Heart and Great Vessels of a Fœtus, showing the angular junction of the Ductus Arteriosus with the Aorta.

inferior vena cava through the right atrium and the foramen ovale into the left atrium ; and the mingled blood passed from the left atrium into the left ventricle, by which it was pumped into the aorta.

It is obvious that the passage of blood from the pulmonary trunk into the aorta could take place only so long as the pressure in the pulmonary trunk was greater than the pressure in the aorta. At birth, when the blood rushes through the rapidly enlarged right and left pulmonary arteries into the lungs as they expand with the first respiratory efforts, the pressure in the pulmonary trunk and the ductus arteriosus is reduced below that in the aorta, and blood would flow from the aorta into the pulmonary trunk through the ductus arteriosus were it not that an alteration of the position of the heart, caused by the expansion of the lungs, produces a twisting of the arterial duct which results in the obliteration of its channel. After blood ceases to flow through the duct, it rapidly contracts and is ultimately reduced to the condition of a fibrous ligament. Occasionally, the duct remains open—usually in association with other abnormalities of the heart and vessels. These anomalous conditions produce peculiar physical signs with which students become acquainted during the course of their work in clinical medicine.

Dissection.—Cut through the remains of the upper part of the infundibulum immediately below the pulmonary valve, and carefully dissect the upper part of the infundibulum and the lower part of the pulmonary trunk away from the front of the lower part of the ascending aorta. Then, turn the lower end of the trunk upwards and pin it to the arch of the aorta (see Fig. 54). The upper part of the anterior wall of the left ventricle and the beginning of the aorta are now exposed, and the dissector should note the three bulgings—*aortic sinuses*—described on p. 79.

Make a transverse incision across the upper end of the left ventricle a short distance below the anterior aortic sinus. On the right side, extend the incision into the upper part of the ventricular septum and carry it downwards, cutting through the anterior part of the septum as far as the apex of the heart. From the left end of the transverse incision, carry an incision downwards and forwards through the left border of the anterior surface of the left ventricle (parallel with the incision already made in the septum) towards the apex. As this incision is made, pull the anterior wall of the left ventricle forwards till the base of a large papillary muscle which springs from its internal surface is exposed. Cut through the base of the papillary muscle ; then, carry the incision onwards to the apex, and remove the anterior wall of the left ventricle and the anterior part of the ventricular septum. The cavity of the left ventricle and the mitral valve are now exposed (Fig. 54).

Left Ventricle.—The cavity of the left ventricle is longer and narrower than that of the right ventricle, and when exposed from the front it appears to be of conical shape. In cross-section it has a circular or broadly oval outline, and its walls are very much thicker than those of the right ventricle (Fig. 51). When the interior has been cleaned with a sponge and forceps, the dissectors will note that its walls are covered with a dense mesh-work of *trabeculæ carneæ*, which are finer and much more numerous than those of the right ventricle. The meshwork is especially complicated at the apex and on the inferior wall of the ventricle, but the surface of the septum and the upper part of the anterior wall are comparatively smooth. But, whilst the trabeculæ carneæ in the left ventricle are slighter and more numerous than those in the right, the *papillary muscles* are less numerous and much stronger ; indeed, as a general rule, there are only two papillary muscles in the left ventricle—a *superior* and an *inferior*—the former attached to the anterior wall of the cavity and the latter to the inferior wall. The *chordæ tendineæ* from each papillary muscle pass to both cusps of the mitral valve—those from the superior muscle being attached to their anterior or left halves, and those from the inferior muscle to their posterior or right halves.

Dissection.—Introduce the blade of a scalpel between the margins of the cusps and carry it between the groups of chordæ to the apex of the superior papillary muscle ; split the muscle, leaving each half connected with a corresponding group of chordæ. The cusps of the mitral valve can now be separated from each other, and the atrio-ventricular orifice and the cavity of the ventricle can be more completely examined.

Orifices of Left Ventricle.—There are two orifices of the left ventricle : one of entrance—the left atrio-ventricular orifice ; and one of exit—the aortic orifice.

Left Atrio-Ventricular Orifice.—This orifice is in the lower and posterior part of the ventricle. It is rather smaller than the right atrio-ventricular orifice and admits the tips of two fingers only—a fact which will be better appreciated when the orifice is examined from the left atrium. It is guarded by a bicuspid valve, known from its appearance as the *mitral valve*, which prevents regurgitation of blood from the left ventricle into the left atrium.

Mitral Valve.—The left atrio-ventricular or mitral valve has two cusps—a large *anterior* and a small *posterior*. Occasionally, however, as on the right side, small additional cusps are interposed between the bases of the main cusps. The bases of the cusps are attached to a fibrous ring which surrounds the atrio-ventricular orifice, and their apices project into the cavity of the ventricle. Their apices, margins and ventricular surfaces give attachment to the chordæ tendineæ, which hold the margins of the cusps together and prevent the valve from being driven backwards into the atrium during the contraction of the ventricle. The dissectors should note, however, that the chordæ tendineæ spread much less over the ventricular surface of the anterior cusp than over that of the posterior cusp, and they should associate this fact with the circumstance that the anterior cusp intervenes between the atrio-ventricular and the aortic orifices, and that the blood therefore flows over both of its surfaces. The blood enters the ventricle through the atrio-ventricular orifice. It runs forwards towards the apex of the cavity over the atrial surface of the anterior cusp of the mitral valve ; then, as the ventricle contracts, it is driven to the aortic orifice over the ventricular surface of the same cusp.

The portion of the cavity of the left ventricle immediately below the aortic orifice is known as the *aortic vestibule*

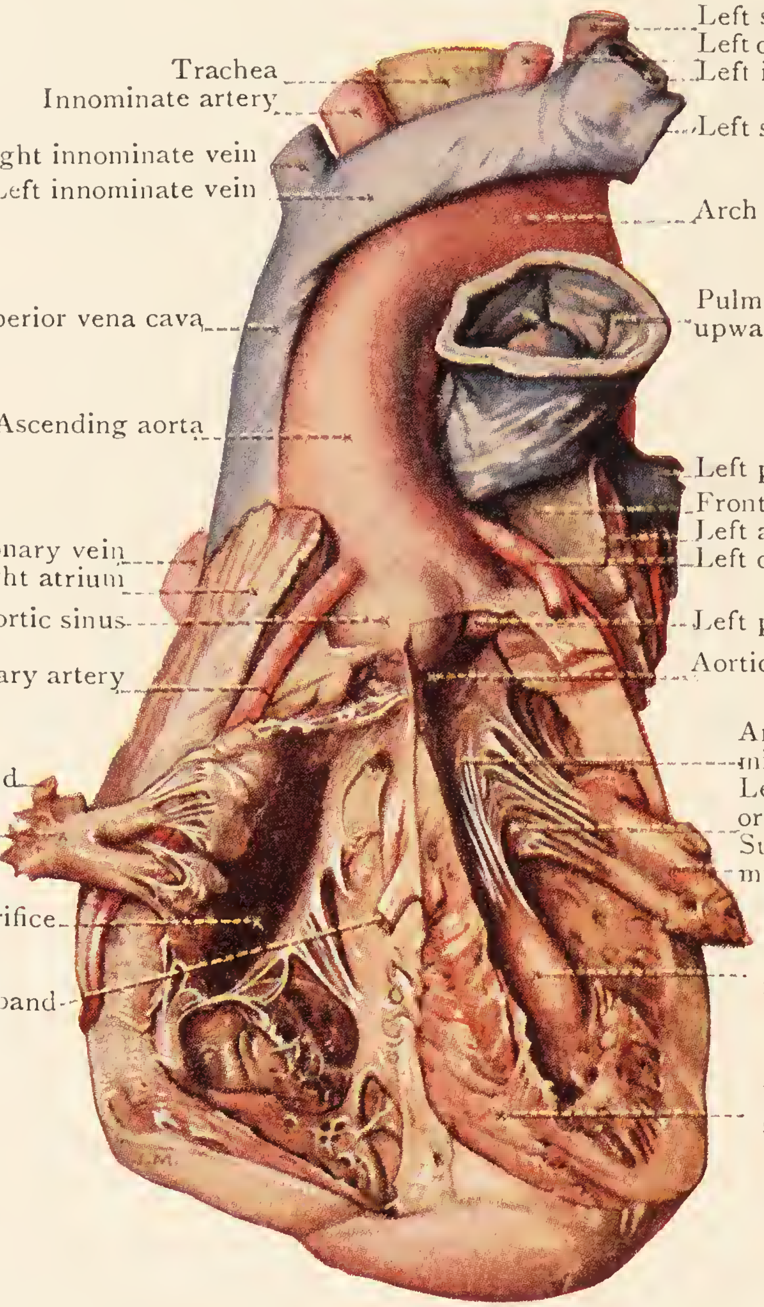


FIG. 54.—Dissection of Ventricles of Heart.

(Fig. 54). Its walls consist mainly of fibrous tissue ; therefore they remain quiescent during the contraction of the ventricle and, as a result, the rapid closure of the aortic valve is not interfered with when the ventricular contraction ceases and the elastic reaction of the walls of the aorta tends to force blood back into the ventricle.

Aortic Orifice.—The aortic orifice is at the upper, right, and posterior part of the cavity, and, like the pulmonary

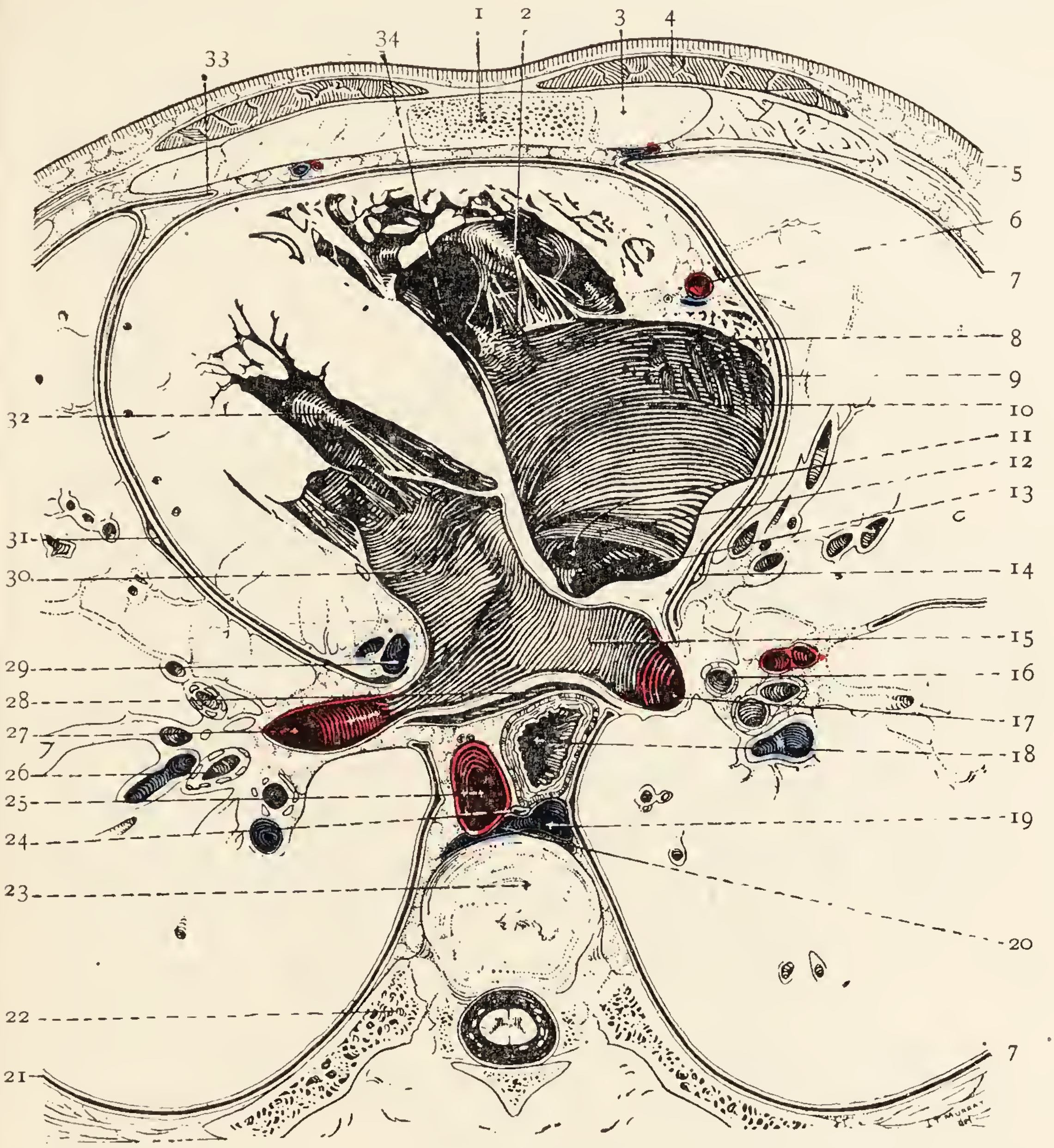


FIG. 55.—Transverse Section through the Thorax of a young man along the plane **D-D**, Fig. 19, p. 39, seen from above.

1. Sternum.
2. Inferior papillary muscle of right ventricle.
3. Fifth costal cartilage.
4. Pectoralis major.
5. Skin.
6. Right coronary artery.
7. Cavity of right pleura.
8. Musculi pectinati.
9. Pericardium.
10. Cavity of right atrium.
11. Opening of hepatic vein.
12. Valve of inferior vena cava.
13. Inferior vena cava.
14. Right phrenic nerve.
15. Left atrium.
16. Right bronchus.
17. Lower right pulmonary vein.
18. Œsophagus.
19. Vena azygos.
20. Superior hemiazygos vein.
21. Cavity of left pleura.
22. Eighth rib.
23. Intervertebral disc between 7th and 8th thoracic vertebræ.
24. Thoracic duct.
25. Descending aorta.
26. Left bronchus.
27. Lower left pulmonary vein.
28. Oblique sinus of pericardium.
29. Coronary sinus.
30. Left atrio-ventricular (mitral) orifice.
31. Left phrenic nerve.
32. Inferior papillary muscle of left ventricle.
33. Anterior margin of left pleura.
34. Septal cusp of r. atrio-ventricular (tricuspid) valve.

orifice, it is surrounded by a fibrous ring to which the cusps of the aortic valve are attached; the left and inferior part of the margin is separated from the atrio-ventricular orifice by the anterior cusp of the mitral valve. The aortic valve guards the orifice, and prevents regurgitation from the aorta into the ventricle.

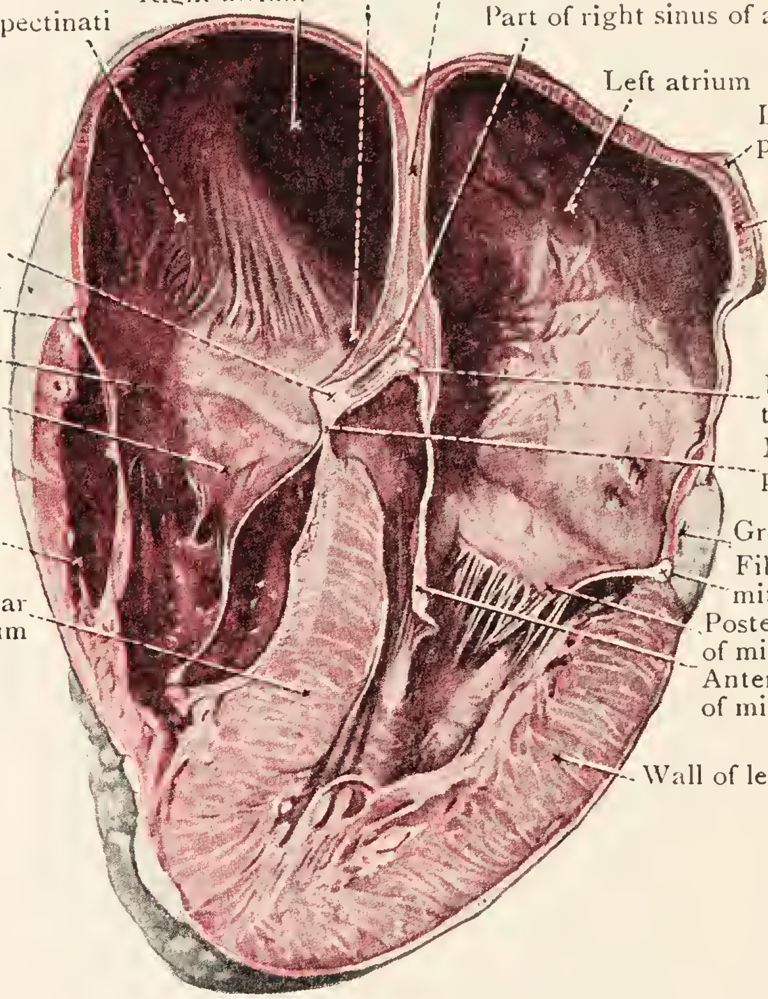


FIG. 56.—Section of Heart showing Ventricular and Atrial Septa and the Fibrous Rings around the Orifices.

Aortic Valve.—The aortic valve, like the pulmonary valve, has three semilunar cusps; but their position is different: one of them is anterior and the other two posterior (Fig. 49). They are stronger than the cusps of the pulmonary valve, but resemble them in all details of structure (p. 93).

Before terminating the examination of the left ventricle, the dissectors should note that the muscular wall of the cavity is thickest a short distance from the atrio-ventricular orifice and thinnest at the apex; and they should examine the ventricular septum.

Ventricular Septum.—This musculo-membranous partition separates the left ventricle not only from the right ventricle but also from the lower part of the right atrium. In the greater part of its extent the septum is thick and muscular, but its upper and posterior part, which is connected with the fibrous rings around the atrio-ventricular and arterial orifices, is membranous (Fig. 56). The *muscular part* of the septum is thickest below and anteriorly, where it springs from the lower border of the heart immediately to the right of the apex, but it becomes gradually thinner as it passes upwards and backwards to its union with the membranous part. The *membranous part* is the thinnest part of the septum. Occasionally it is deficient in whole or in part; a communication then exists between the two ventricles and, in some rare cases, between the left ventricle and the right atrium.

The membranous part of the septum will be exposed, from the right side, when the anterior part of the medial cusp of the tricuspid valve is removed in the dissection of the atrio-ventricular bundle (see p. 110 and Figs. 60, 61).

Finally, the dissectors should note :—(1) that the ventricular septum is placed obliquely, so that its anterior border lies to the left and its inferior border to the right; and (2) that its right surface looks forwards as well as to the right and bulges towards the cavity of the right ventricle (Fig. 51).

Aorta.—The aorta is the great arterial trunk of the body. It springs from the upper, posterior and right portion of the left ventricle, at the level of the third intercostal space and opposite the left margin of the sternum. It terminates on the front of the fourth lumbar vertebra to the left of the median plane, where it divides into the right and left common iliac arteries. For descriptive purposes, it is divided into three main parts :—(1) the ascending aorta, (2) the arch of the aorta, and (3) the descending aorta. The descending aorta is subdivided into (*a*) the descending thoracic aorta and (*b*) the abdominal aorta.

Ascending Aorta.—The ascending aorta (Figs. 26, 35, 54, 57) springs from the left ventricle at the aortic orifice and runs upwards and to the right and slightly forwards, behind the first piece of the body of the sternum, to the level of the sternal end of the second right costal cartilage, where it becomes the arch of the aorta. It lies in the middle mediastinum, within the fibrous pericardium, and is ensheathed in a covering of the serous pericardium which is common to it and the pulmonary trunk. The lumen of the ascending aorta is not of uniform diameter; on the contrary, it presents four dilatations—the three *aortic sinuses* at its root, and a slight bulging along its right border, sometimes called the *great*

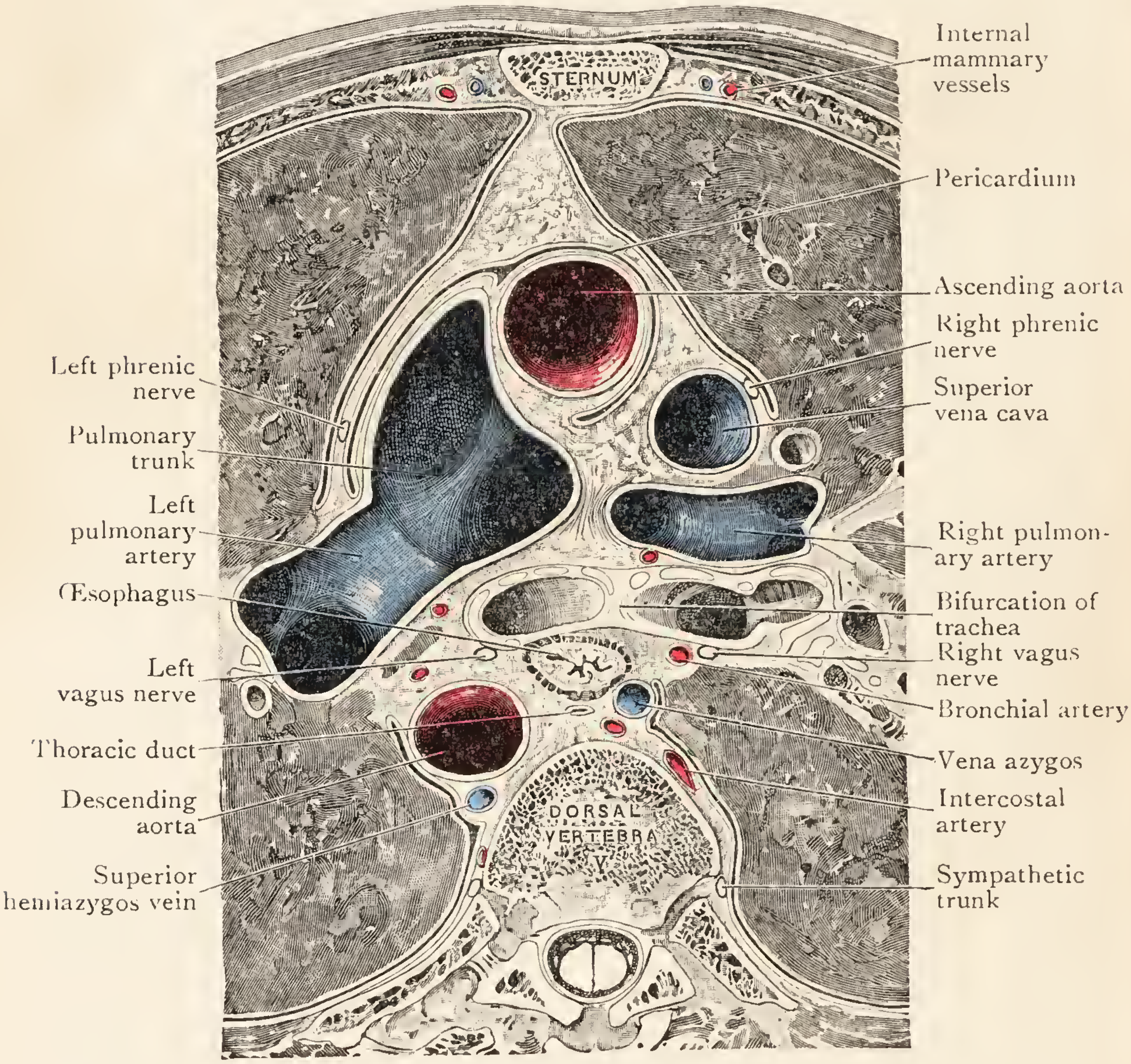


FIG. 57.—Transverse Section through Mediastinum at the level of fifth thoracic vertebra.

sinus. The great sinus, though ill-defined, is of interest as the common site for the commencement of an aneurysm of the aorta.

Relations.—The lower part of the ascending aorta is behind the upper part of the infundibulum and the root of the pulmonary trunk; but the upper part is in direct relation anteriorly with the pericardium, which separates it from the anterior parts of both pleuræ and lungs. Behind the ascending aorta there are, from below upwards, the atria, the right pulmonary artery and the right bronchus. On its right side, the lower part is related to the auricle of the right atrium, and the upper part to the superior vena cava. Its left side is related to the left auricle, below, and to the upper part of the pulmonary trunk, above.

Branches.—The only branches of the ascending aorta are the right and left coronary arteries (p. 79).

Arch of Aorta.—The arch is continuous with the ascending aorta at the level of the second costal cartilage, opposite the right margin of the sternum, from which it is separated by the anterior part of the right pleura and lung, or by the remains of the thymus (Figs. 28, 58); and it runs its course through the lower part of the superior mediastinum. It passes first to the left and slightly upwards, behind the lower half of the manubrium sterni and in front of the lowest part of the trachea, and then *backwards* across the left side of the trachea and œsophagus (see Figs. 28 and 58) to reach the lower border of the left side of the fourth thoracic vertebra, where it becomes continuous with the descending aorta. It is curved in both the vertical and the horizontal planes, forming a convexity upwards and also a convexity towards the left and forwards. Its lower border is connected with the left pulmonary artery by the ligamentum arteriosum, and from its upper border arise the three great vessels which supply the head, neck and upper limbs (Figs. 38, 42).

Relations.—*Above*, the left innominate vein runs along its upper border, in front of the branches of the arch. The innominate artery arises from the arch behind the centre of the manubrium sterni, or a little to the left of the centre; the left common carotid artery arises close to the innominate artery, and sometimes in common with it; and the origin of the left subclavian artery is farther back and a little to the left, separated by a distinct interval from the left common carotid.

Below the arch there are:—(1) the bifurcation of the pulmonary trunk; (2) the ligamentum arteriosum, which connects the root of the left pulmonary artery with the arch; (3) the superficial cardiac plexus, in front of the ligamentum arteriosum; (4) the left recurrent laryngeal nerve, behind the ligament; and (5), still farther back, the left bronchus passes beneath the arch on its way to the hilum of the left lung.

To the right of the arch, and also behind its anterior part, there are the trachea, the œsophagus, the left recurrent laryngeal nerve, and the thoracic duct. The nerve lies between the œsophagus and the trachea, and the duct is near the left side of the œsophagus (Fig. 58). The *left side* of the arch is

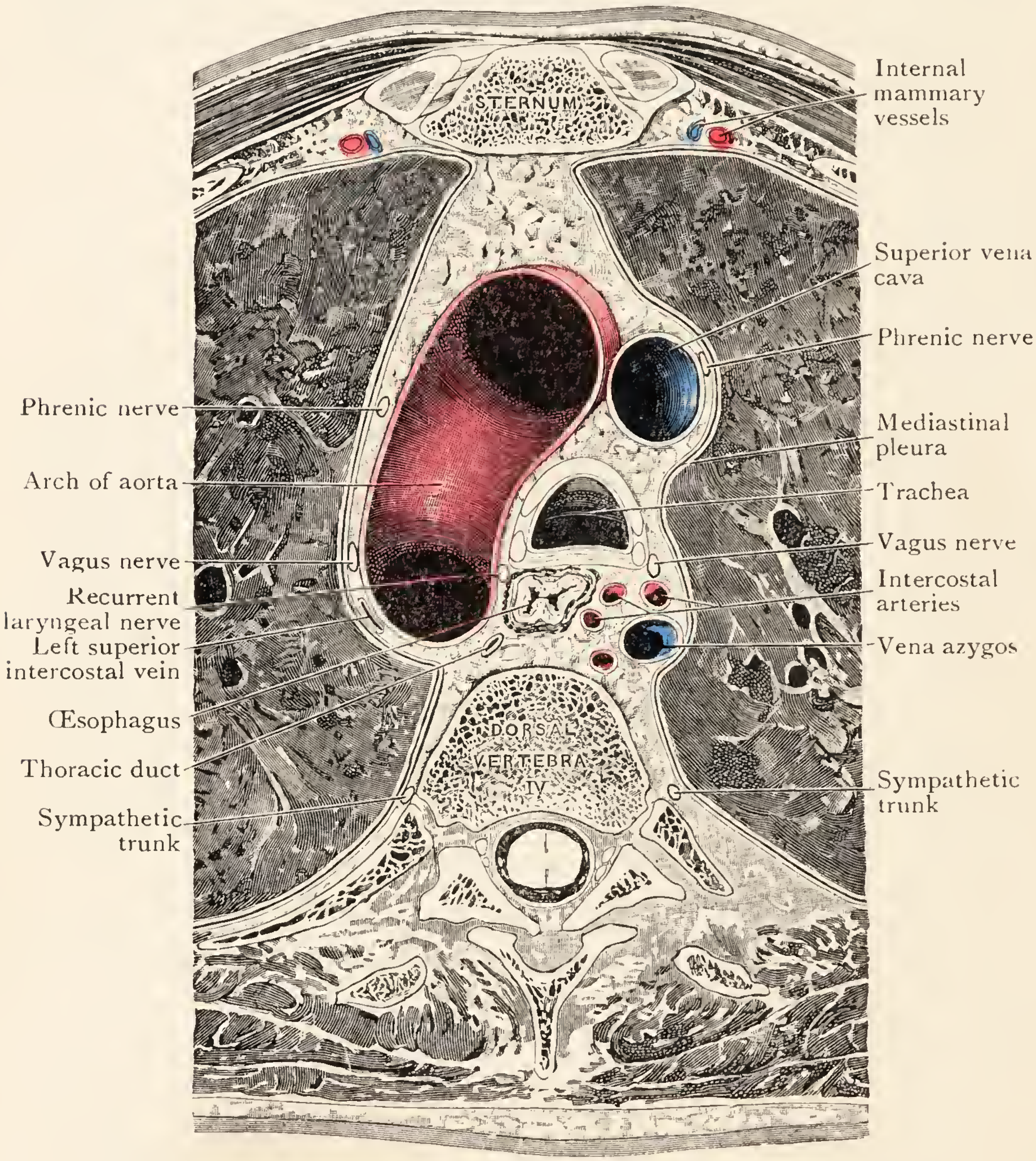


FIG. 58.—Transverse Section through Superior Mediastinum at the level of fourth thoracic vertebra.

closely related to the mediastinal surface of the left pleura and lung. But intervening between the pleura and the arch there are :—(1) the remains of the thymus gland, (2) the left phrenic nerve, (3) the inferior cervical cardiac branch of the left vagus, (4) the superior cervical cardiac branch of the left sympathetic trunk, (5) the left vagus, and (6) the left superior intercostal vein. The vein passes upwards and forwards, lying lateral to the vagus and the cardiac nerves, and medial to the phrenic nerve (Figs. 18, 42, 58).

Dissection.—Divide the right coronary artery close to its origin. Cut through the anterior wall of the ascending aorta on each side of the anterior aortic sinus ; extend the incisions upwards to the beginning of the aortic arch, raise up the flap and examine the aortic valve (p. 100) and the relation of the origin of the coronary arteries to its cusps (p. 79).

Replace the pulmonary trunk ; replace the sternum also, and revise the surface-anatomy of the orifices of the heart (p. 74) ; and then proceed to remove the heart.

Dissection.—Divide the phrenic nerves immediately above the diaphragm and detach the pericardium from the diaphragm ; the knife may be required for the separation of the pericardium from the central tendon.

Divide the right innominate vein and the right phrenic nerve immediately above the superior vena cava, taking care not to injure the right vagus. Divide the vena azygos close to the superior vena cava. Cut the inferior thyroid veins, the innominate artery and the left common carotid artery, immediately above the left innominate vein ; then, if the left innominate vein has not already been divided, divide it in the interval between the left common carotid and the left subclavian arteries. Cut the left phrenic nerve immediately above the aortic arch, severing, at the same time, the two small cardiac nerves that descend behind the phrenic nerve.

Divide the aortic arch. Enter the knife at its upper border, between the left common carotid and subclavian arteries, in front of the left vagus and the left recurrent laryngeal nerve, and cut from above downwards, completing the division immediately behind the ligamentum arteriosum. The left superior intercostal vein will be divided at the same time, but care must be taken not to injure the left recurrent laryngeal nerve.

When the incisions are completed, pull forwards the anterior part of the aortic arch, with the superior vena cava, the lower parts of the innominate veins, and pulmonary trunk and arteries —separating them from the lower part of the trachea and from the bronchi. As the separation proceeds, keep the edge of the knife turned towards the aortic arch to avoid injury to the deep cardiac plexus, which lies on the bifurcation of the trachea. When the lower border of the arch is reached, the twigs which connect the superficial and deep cardiac plexuses will be exposed, and must be divided. Next, detach the pericardium from the œsophagus and the descending aorta, taking care to avoid injury to the plexus formed by the vagi nerves on the œsophagus.

Remove the heart and attached vessels, with the remains of the pericardium and the lower parts of the phrenic nerves, from the thorax ; fasten the left vagus and the recurrent laryngeal nerve to the part of the arch left *in situ* by one or two points of suture ; and, finally, return to the heart and cut away the remains of the pericardium, leaving only those portions of it which mark the lines of reflexion of the serous layer.

The dissectors will now examine the left atrium, and will afterwards investigate the structure of the heart.

Left Atrium.—Like the right atrium, the left has a main portion—the atrium proper—and an auricle, which is long and narrow, and projects forwards and to the right from the

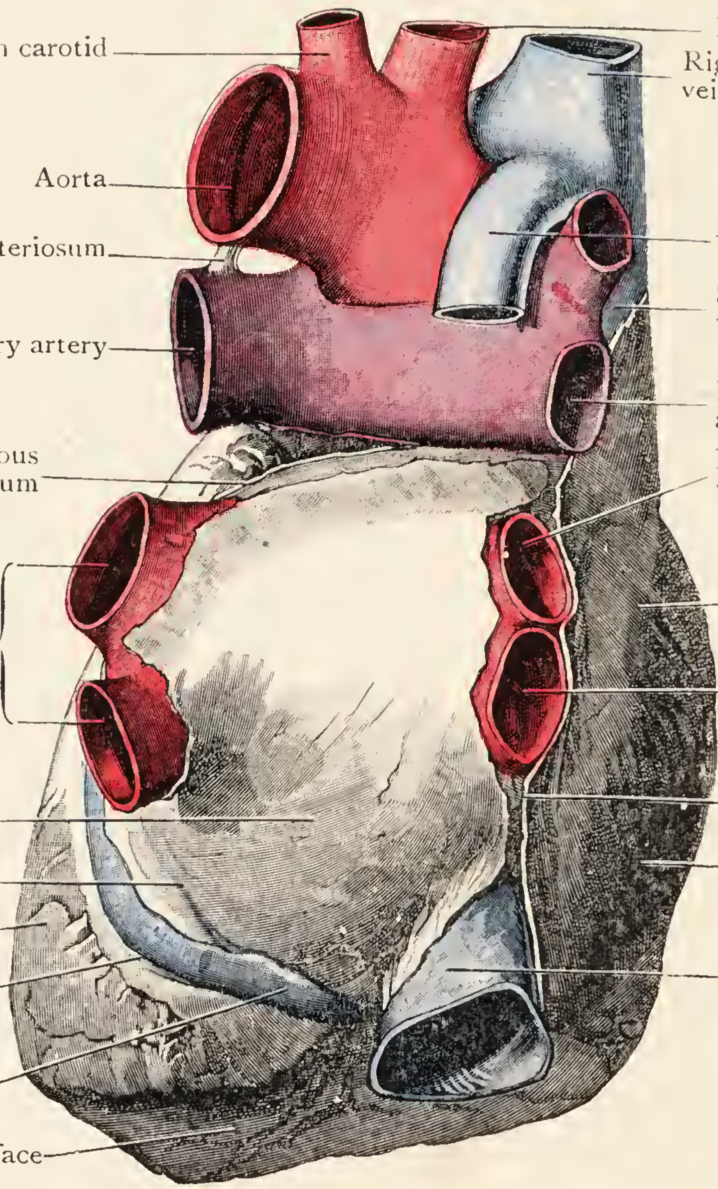


FIG. 59.—Heart and Great Vessels from behind. The specimen was hardened *in situ* by formalin-injection.

upper and anterior angle of the atrium, The four pulmonary veins, two on each side, open into the left atrium. They enter close to the upper ends of the right and left borders of the posterior surface, and not uncommonly, on one or both sides, the two veins fuse into a common trunk at or near the point of entrance.

The left atrium forms a great part of the base of the heart, a small part of the sterno-costal surface, and a still smaller part of the left surface. The only part which can be seen from the front, when the heart and great arteries are *in situ*, is the apical portion of the auricle, for the portion which enters into the formation of the sterno-costal surface is hidden by the aorta and the pulmonary trunk (Fig. 38).

The posterior wall of the left atrium is of quadrangular outline. The right and left pulmonary arteries run along its upper border; and the coronary sinus runs along its lower border in the posterior part of the atrio-ventricular groove. On the right, immediately in front of the right pulmonary veins, it is bounded by an indistinct groove which indicates the position of the posterior border of the atrial septum. A slender vein—the *oblique vein of the left atrium*—passes obliquely downwards and to the right across the posterior wall of the left atrium, from the lower border of the lower left pulmonary vein to the coronary sinus. It is a vestige of the left Duct of Cuvier of the fœtus. On the rare occasions in which there is a left superior vena cava, the duct persists as the lower part of it.

Dissection.—Open the left atrium by three incisions—one horizontal and two vertical. Make the horizontal incision along the lower border of the back of the atrium; and run the vertical incisions from the ends of the horizontal incision to the upper border, each passing to the medial side of the terminations of the corresponding pulmonary veins. Turn the posterior wall of the atrium upwards while the cavity is being examined. From the left vertical incision carry the knife forwards through the lateral wall of the auricle.

Interior of Left Atrium (Figs. 41, 55, 56).—The inner surface of the wall of the left atrium is smooth and generally devoid of muscular bundles; but it will be noted that the inner surface of the wall of its auricle is covered with musculi pectinati. They are confined to the auricle, and they do not spring from a crest as in the right atrium. In a formalin-hardened heart, however, the dissectors will find a prominent muscular ridge which descends from the posterior margin of the cavity of the auricle along the left border of the cavity of the atrium in front of the orifices of the left pulmonary veins, entirely concealing them from view when the cavity is examined from the front.

Orifices of Left Atrium.—These are the openings of the *four pulmonary veins*, the *left atrio-ventricular orifice*, and the mouths of the *venæ cordis minimæ*.

The pulmonary veins convey oxygenated blood from the lungs to the atrium. Through the venæ cordis minimæ a small amount of venous blood from the walls of the atrium is passed into its cavity. Through the left atrio-ventricular orifice the blood passes from the left atrium into the left ventricle.

The openings of the pulmonary veins are in the posterior wall of the atrium, nearer the upper than the lower part, and close to the right and left borders ; they have no valves. The orifices of the venæ cordis minimæ are very minute, are scattered irregularly, and also are valveless. But the left atrio-ventricular orifice, which is in the lower part of the anterior wall of the atrium, is guarded by the mitral valve (p. 97).

Structure of Walls of Heart.—The last step in the dissection of the heart is the examination of the structure of its walls. On the outside, the walls are covered with the *epicardium*, which is the visceral part of the serous pericardium. On the inside, they are lined with a smooth and glistening membrane called the *endocardium*, which plays a large part in the formation of the flaps of the valves, and is continuous, through the orifices, with the inner coats of the arteries and veins. The muscular tissue of the heart lies between the epicardium and the endocardium and is termed the *myocardium*. The muscular fibres of the myocardium are embedded in areolar tissue which extends from the epicardium to the endocardium ; and they are disposed in layers in each of which the fibres take a special direction.

The arrangement of the various layers of the myocardium cannot be displayed in a heart in which the continuity of the fibres has been destroyed by the incisions made to display the cavities, but the arrangement of the layers is practically the same in the hearts of all mammals. Therefore, for the purpose of studying the layers, the dissectors should obtain a sheep's heart. Fill the heart with a paste made of flour and water, and boil it for a quarter of an hour. The boiling expands the paste, softens the fibrous tissue, and hardens the muscular fibres. After the boiling is finished, the heart should be placed for a time in cold water. When it has cooled, first the epicardium and then the muscular fibres should be gradually torn off.

The atrial fibres are difficult to dissect. They are arranged in three groups :—(1) Superficial fibres that run more or less transversely and are common to both atria ; they are best marked near the atrio-ventricular groove. (2) A deep group, special to each atrium ; the extremities of the fibres of the deep group are connected with the atrio-ventricular fibrous rings, and they pass over the atria from front to back. (3) The third group consists of sets of annular fibres that surround the orifices of the veins which open into the atria.

The fibres of the ventricles are more easily dissected. They are arranged, for the main part, in two groups—a superficial and a deep. The fibres of each set are common to both ventricles, and the dissectors should note the remarkable spiral or whorled arrangement of the superficial fibres which occurs at the apex, where they pass into the deeper parts of the wall.

The superficial fibres spring mainly from the atrio-ventricular fibrous rings. Those which are attached to the right ring turn inwards at the apex and become continuous with the papillary muscles of the left ventricle; and the fibres which spring from the left ring pass in the same way to the papillary muscles of the right ventricle. The deeper fibres form an ∽-shaped layer, one loop of the ∽ surrounding the right ventricle and the other the left ventricle.

The fibrous rings of the atrio-ventricular orifices intervene between the atrial and the ventricular muscle-fibres, and the only connexion between the two groups, from the functional point of view, is by means of the atrio-ventricular bundle, which is part of the conducting system of the heart. Before making an attempt to display the parts of this system, the dissectors should understand the sequence of events in the cycle of the heart's contraction and dilatation.

Action of the Heart.—The differences between the various parts of the heart, *e.g.*, the relative thickness of the walls of the chambers, are associated with the functions of the various chambers and with the action which the heart plays in the maintenance of the circulation of the blood. The heart is a muscular pump provided with receiving and ejecting chambers. It has three phases of action:—(1) a period of atrial contraction; (2) a period of ventricular contraction, which immediately succeeds the atrial contraction; (3) a period of diastole or rest.

During the period of rest the chambers, previously contracted, expand as the muscular fibres of the heart relax. The expansion is aided by the respiratory movements of the thorax, and, as it progresses, blood flows into the right atrium from the venæ cavæ and the coronary sinus, and into the left atrium through the four pulmonary veins. As the blood enters the atria, it begins at once to flow into the ventricles through the atrio-ventricular orifices, for they are open; and the onward movement is completed by the contraction of the atria. The atrial contraction begins with the contraction of the circular fibres around the mouths of the veins that enter the atria, and thus the blood is prevented from passing back into the veins. As the contraction spreads, the atria are emptied and the ventricles become distended. Then the ventricular contraction begins, the atrio-ventricular valves close, the arterial valves open, and, as the contraction proceeds, the blood is driven out of the ventricles through the arterial orifices—from the right ventricle into the pulmonary trunk, and from the left ventricle into the aorta.

When the ventricular contraction is completed, the period of systole is at an end and the period of diastole begins; and, as long as the heart remains alive, the cycle is repeated.

Until the ventricular contraction begins, the atrio-ventricular orifices are widely open, and the work of the atria is merely to complete the discharge of the blood through them into the ventricles and to expand the ventricles. For that purpose no great force is required, and the walls of the atria are therefore thin. The work of the ventricles is much more severe; their walls are therefore thicker. The right ventricle, however, has only to exert sufficient force to drive the blood through the lungs to the left atrium—that is, through a comparatively short distance and against a relatively small resistance. Its walls are therefore thin as compared with the walls of the left ventricle, which have to be sufficiently strong to force the blood through the whole body. The pressure created in the aorta (150 mm. Hg.) is about three times as great as that in the pulmonary arteries; corresponding to the relation between these pressures is the fact that the left ventricular wall is about three times as thick as the right.

The dissectors will now attempt to expose the atrio-ventricular bundle. It is only occasionally that this bundle can be displayed in the heart of an ordinary dissecting-room body ; but it is very readily dissected in the heart of a sheep or a calf, and one of these should be procured for the purpose.

Dissection.—Detach the antero-superior part of the medial cusp of the tricuspid valve from the atrio-ventricular fibrous ring. The membranous part of the ventricular septum is

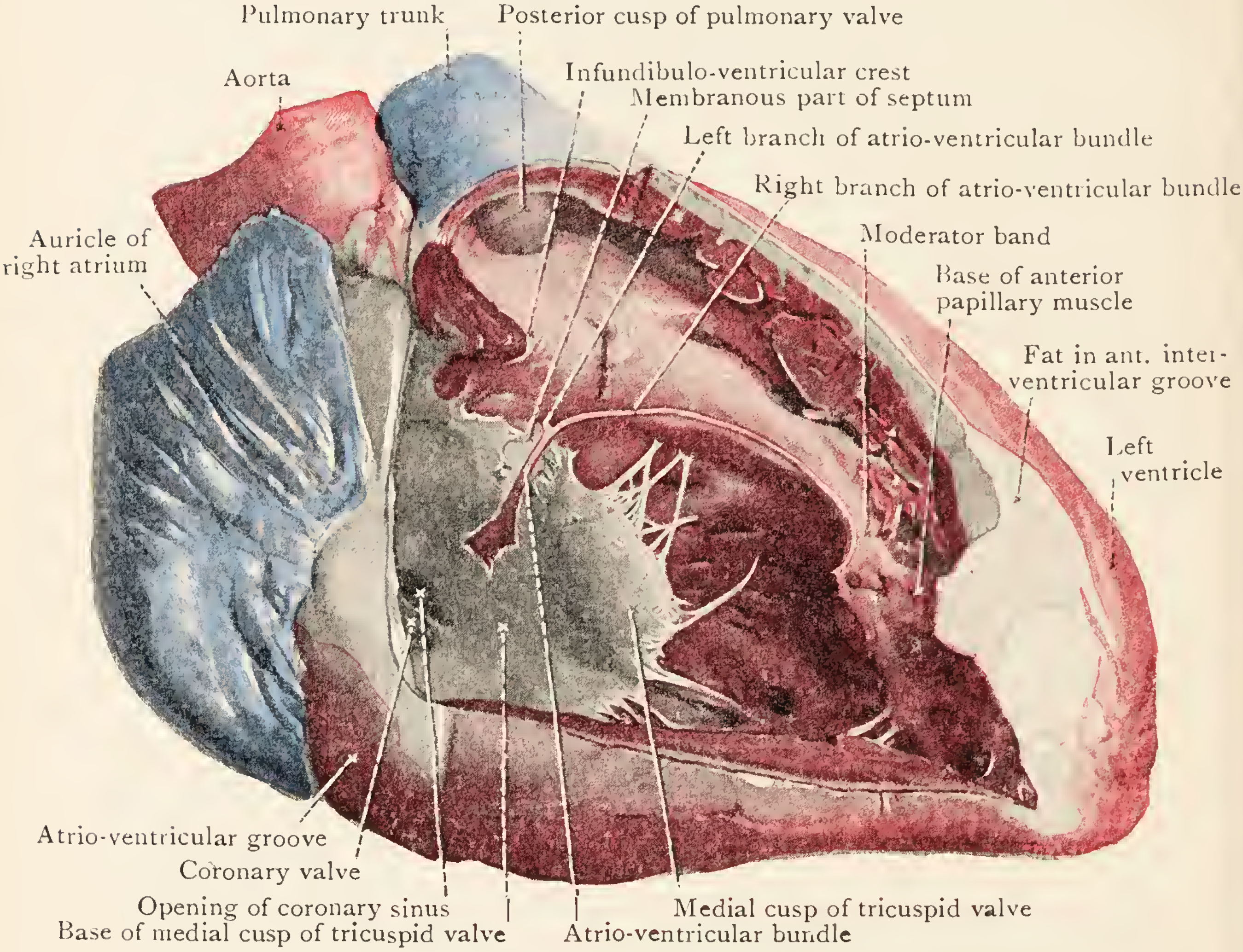


FIG. 60.—Dissection of Right Ventricle showing the course and division of the Atrio-Ventricular Bundle.

then exposed and the *atrio-ventricular bundle*, which can be recognised as a small bundle of pale fibres under cover of the endocardium, will be found running along its lower and anterior border to the upper end of the muscular part of the ventricular septum, where it divides into right and left branches. Trace the right branch along the right side of the septum to the moderator band, and then attempt to follow the left branch between the membranous and muscular parts of the septum. In the heart of a sheep or a calf, the dissectors will find that they can recognise the right and left branches of the bundle on the walls of the ventricular septum, can establish their continuity by cutting away the whole thickness of the ventricular septum at the proper level, and can also trace the main bundle (having cut away the medial cusp of the tricuspid valve) across the atrio-ventricular junction to the *atrio-ventricular node*, which lies in the septal wall of the right atrium immediately behind the opening of the coronary sinus.

Conducting System of Heart (Neuro-Myocardium).—The function of initiating the sequence of events in the cycle of heart-action, of controlling its regularity, and of transmitting the impulses from atria to ventricles, resides in certain special parts of the myocardium. Cardiac muscle has the property of rhythmic contraction. One collection of the special myocardial tissue, situated in the wall of the right atrium, sets the pace of the rhythm. Another part begins in the wall of the right atrium, extends across the otherwise fibrous atrio-ventricular junction, and spreads out to form a sub-endocardial network in the walls of the ventricles ; this part propagates the rhythm of the atrial contraction to the ventricles. If the connecting link is severed, experimentally or by disease, the remarkable result follows that the ventricles contract independently of the atria, and with a much slower rhythm. This condition is known as " heart-block."

The parts concerned in this controlling and conducting mechanism are composed of a special myocardial tissue distinguished from the ordinary cardiac muscle not only because it is less highly differentiated from the original cells but also because the muscle-fibres are intimately associated with numerous nerve-cells and nerve-fibrils which probably have a share in the initiation and transmission of the rhythmic contractions of the heart. The functional connexion between the parts of the heart has thus a neuro-muscular basis ; and the system as a whole may therefore be distinguished as the " neuro-myocardium." Its parts are named the *sinu-atrial node*, the *atrio-ventricular node*, and the *atrio-ventricular bundle* with its right and left septal divisions, which end in the *terminal sub-endocardial network.*

The **sinu-atrial node** (Keith and Flack) is a small collection of vascular neuro-myocardium situated in the wall of the right atrium at the upper end of the crista terminalis.

The **atrio-ventricular node** (Tawara) is a nodule of the same kind of vascular tissue situated in the septal wall of the right atrium immediately behind the opening of the coronary sinus.

The **atrio-ventricular bundle** (Kent, His) is a pale bundle, about the thickness of a match, of the special muscle-fibres with which nerve-fibres are associated. It springs from the " A-V " node, runs forwards on the septum, passes through the atrio-ventricular fibrous junction, and appears beneath the endocardium of the right ventricle under cover of the medial cusp of the tricuspid valve. There, it swells out a little, and then passes forwards along the lower and anterior border of the membranous part of the interventricular septum to the posterior end of the muscular part of that septum, where it divides into right and left branches (Figs. 60, 61).

The *right septal division* continues the course of the main bundle on the muscular part of the septum towards the moderator band, along which it passes from the septum to the anterior wall of the ventricle, which it reaches at the base of the anterior papillary muscle. Fine branches arise from it as it reaches the moderator band, and these continue along the septum to the base of the inferior papillary muscle. One or two of them occasionally appear as free threads that pass across the cavity of the ventricle.

The *left septal division* pierces the ventricular septum between its membranous and muscular parts, and appears on the left side of the septum, along which it runs, as a flattened band, to the base of the inferior papillary muscle of the left ventricle. During its course on the septum, two or three fine strands usually spring from it and pass across the cavity of the ventricle to the base of the superior papillary muscle. These strands are very distinct in the hearts of the sheep and calf, in which both

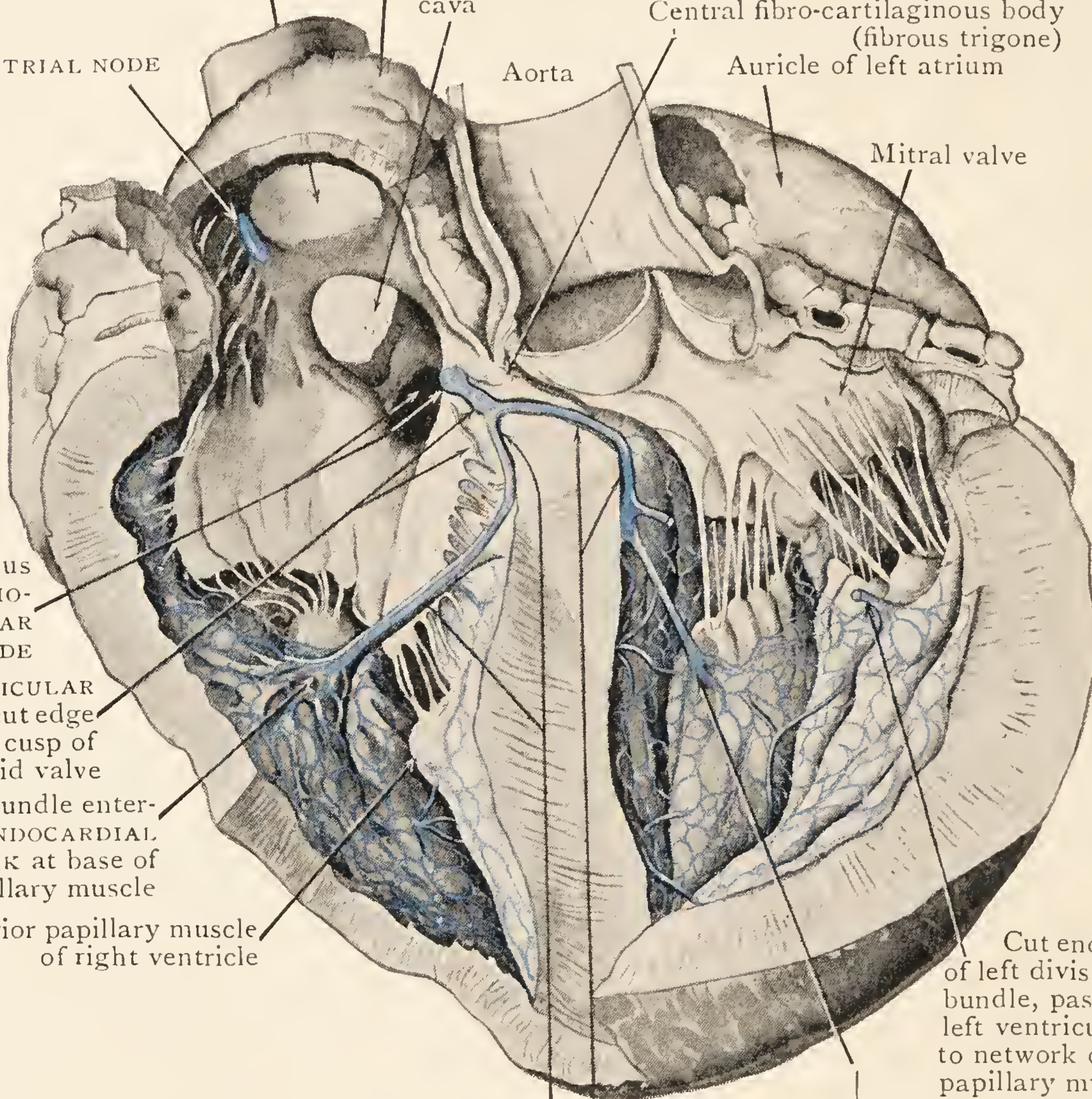


FIG. 61.—Conducting System of a Sheep's Heart; from dissected and injected specimens.

(For the position of the fibrous trigone, and the membranous and muscular parts of the ventricular septum in the human heart, see Fig. 56, p. 100.)

septal branches and the network in which they end can be recognised very easily by the naked eye as whitish structures beneath the endocardium.

The **terminal sub-endocardial network** (Purkinje) is spread out beneath the endocardium of the greater part of both ventricles. It receives the branches of the bundle at the bases of the papillary muscles, which are consequently the first parts of the ventricles to contract. The network forms a characteristic collar around each papillary muscle, the apex of the muscle being free of the network. The meshes of the network become finer and then disappear towards the atrio-ventricular and arterial orifices of the ventricles. A striking picture of the distribution of the sub-endocardial network and of the course of the bundle and its branches may be obtained by the injection of Indian ink or other suitable coloured liquid into the sheath which surrounds the whole system. Good results are obtained most easily in the heart of an ungulate (Fig. 61).

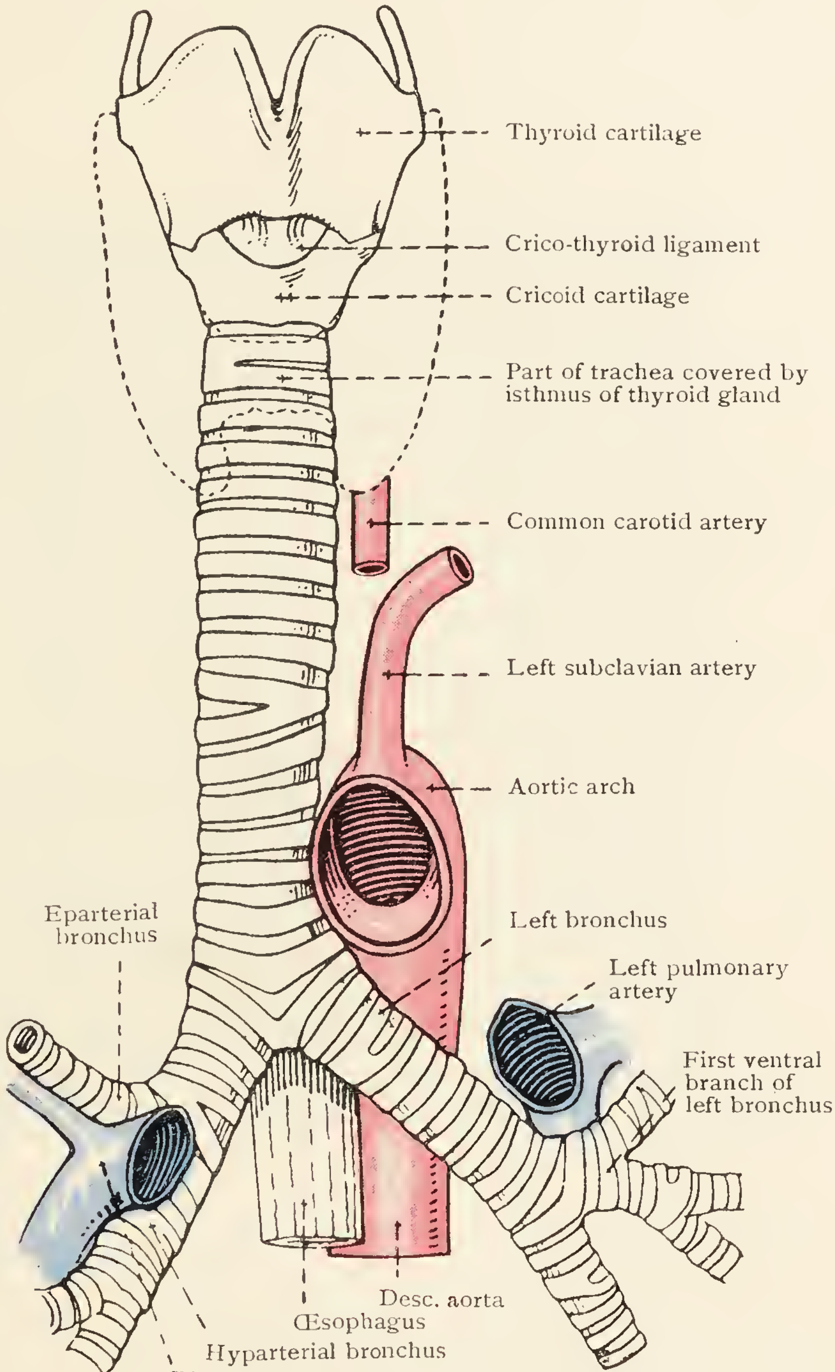


FIG. 62.—Larynx, Trachea and Bronchi. The dotted line gives the outline of thyroid gland.

Having completed the examination of the heart, the dissectors will now return to the cavity of the thorax and resume the examination of the structures in the superior and posterior mediastina.

Thoracic Portion of Trachea.—The trachea is a wide tube, from four to five inches in length, kept constantly patent by a series of curved cartilaginous bars which are embedded in its walls ; the bars are deficient posteriorly, and, in consequence, the back of the tube is flattened (Fig. 58). It begins in the neck at the lower end of the larynx, and about half of it is in the neck and half in the thorax. It enters the inlet of the thorax opposite the upper border of the manubrium sterni, and it terminates at the level of the lower border of the manubrium and opposite the interval between the third and fourth thoracic spines by dividing into a right and a left bronchus; its thoracic part is therefore opposite the manubrium and wholly in the superior mediastinum. Its median axis is

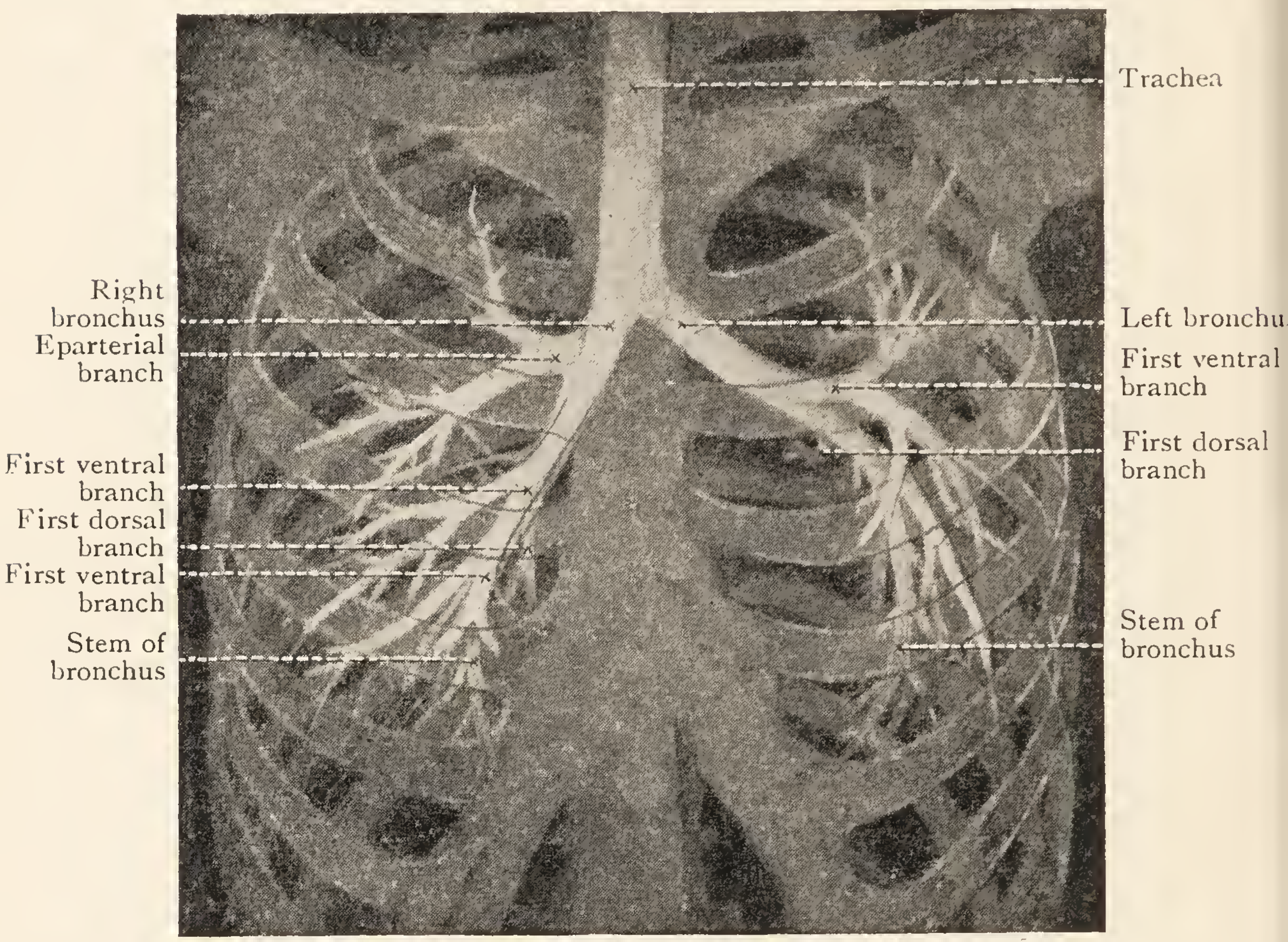


FIG. 63.—Drawing of a Stereoscopic Radiograph of Trachea and Bronchi injected with starch and red lead.

in the median plane except in its lower part, where it deviates slightly to the right.

Relations.—Posteriorly, it is in contact with the œsophagus, which separates it from the vertebral column; and the left recurrent laryngeal nerve ascends in the groove between its left border and the œsophagus (Fig. 58).

Anteriorly, its lower part is crossed by the anterior part of the arch of the aorta, with the deep cardiac plexus intervening; at a higher level, it is related to the innominate and left common carotid arteries, with the left innominate vein and the remains of the thymus in front of them; and, still farther forwards, the manubrium sterni with the lower parts of the sterno-hyoid and sterno-thyroid muscles, which arise from the back of it.

On the right, it is in relation with the right pleura and lung (Fig. 58), the right vagus nerve, and the arch of the azygos vein (Fig. 17). The right innominate vein and the superior vena cava also are to the right, but are on a more anterior plane

The upper part of its *left side* is related to the left common carotid and subclavian arteries and the phrenic and vagus nerves (Fig 36), and the lower part to the arch of the aorta (Fig. 58) ; and they separate it from the left pleura and lung.

Bronchi.—Each bronchus passes downwards and sidewards, first to the hilum of the corresponding lung, and thence downwards in the substance of the lung towards its base. It can be divided, therefore, into an extrapulmonary and an intrapulmonary portion. The extrapulmonary part is kept permanently open by curved cartilaginous bars which are like those in the trachea, and it is therefore flattened posteriorly. The intrapulmonary parts of the bronchi are kept patent by cartilaginous plates which are irregularly distributed in the substance of their walls.

Relations of Extrapulmonary Bronchi.—The **right bronchus** is about one inch long ; it is more vertical than the left (Fig. 63), and is slightly wider ; foreign bodies which have entered the windpipe pass, therefore, more frequently into it than into the left bronchus. *Anterior* to it there are the right pulmonary artery, the pericardium, the lower part of the superior vena cava, and the ascending aorta. The arch of the azygos vein is *above* it ; and *posterior* to it there are the bronchial vessels and the posterior pulmonary plexus.

It gives off one branch, which arises close to the hilum and is called the *eparterial bronchus* because it originates immediately above the point where the right pulmonary artery crosses in front of the stem-bronchus.

The **left bronchus** has farther to go than the right bronchus because the hilum of the left lung is farther from the median plane than the hilum of the right lung is ; it is therefore nearly twice as long as the right bronchus, and it is less vertical. It gives off no branches.

Anterior to it there are the left pulmonary artery and the pericardium, which separates the bronchus from the left atrium. The arch of the aorta is *above* it; and *posterior* to it there are the bronchial vessels, the posterior pulmonary plexus, the œsophagus, and the descending aorta.

The intrapulmonary parts of the bronchi and their rela-

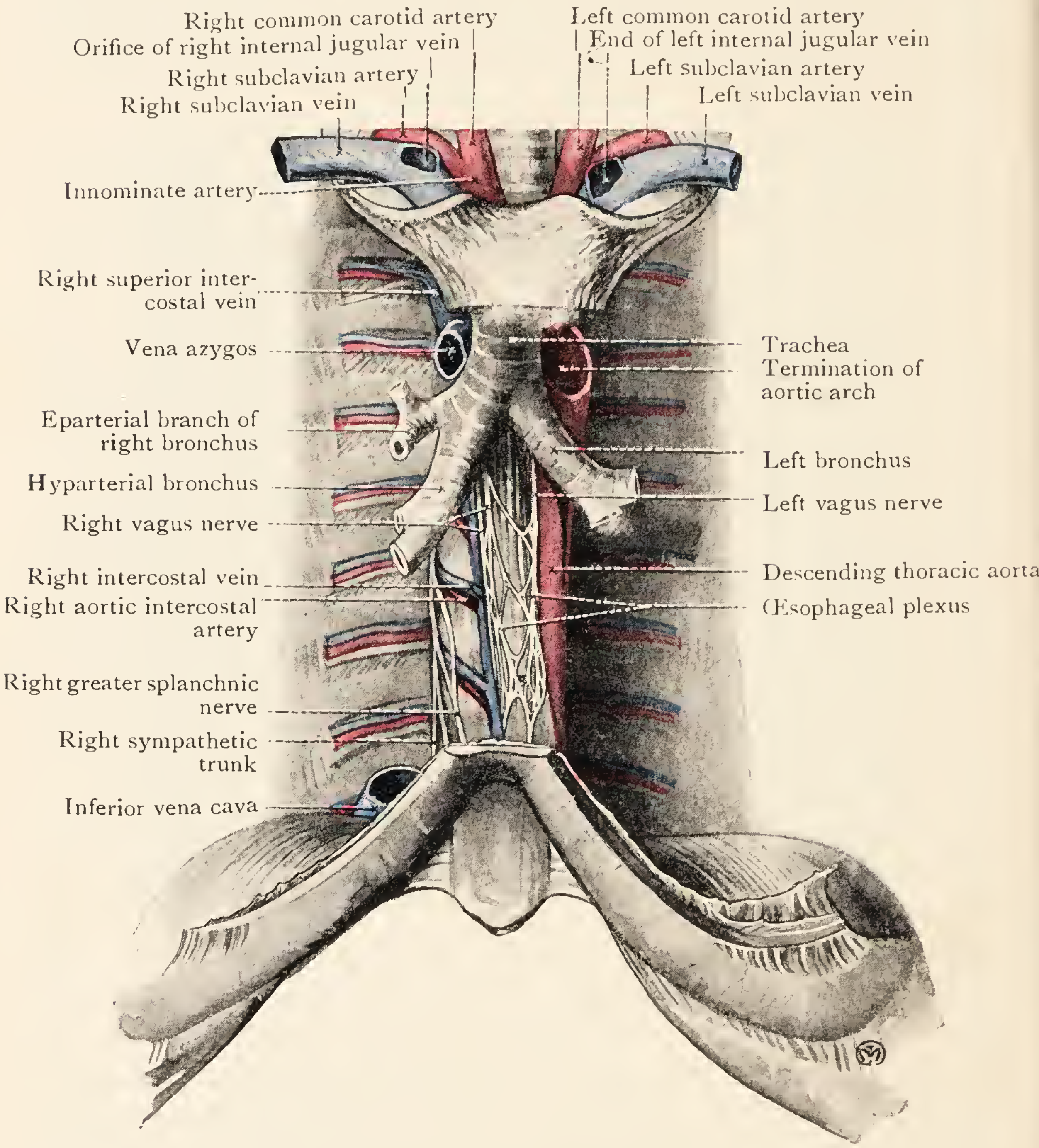


FIG. 64.—Dissection of Posterior Mediastinum and posterior part of Superior Mediastinum, from the front.

tions have already been examined (p. 53). Their positions in relation to the thoracic wall and to the heart as shown by radiography may be seen in Figs. 7, 8, 24, 63, 65.

THORACIC PORTIONS OF VAGI NERVES.—Both vagi enter the thorax at the inlet, and their thoracic parts, which are still in position, should now be examined.

Right Vagus.—The right vagus passes downwards and backwards between the trachea and the right pleura as far as the azygos vein (Fig. 17). Next, it passes between the trachea and the arch of the azygos vein, and reaches the back of the root of the right lung, where it breaks up into a number of branches which form the main part of the posterior pulmonary plexus. It emerges from the plexus usually as a single trunk which runs downwards and medially into the posterior mediastinum to reach the œsophagus and take part in the *œsophageal plexus* (Figs. 37, 64).

Thoracic Branches of Right Vagus.—It gives off :—(1) a cardiac branch which arises on the side of the trachea and runs downwards over the trachea to the deep cardiac plexus ; (2) branches to the bronchi and the lung through the pulmonary plexuses ; and (3) branches to the œsophagus and the pericardium through the œsophageal plexus.

Left Vagus.—In the superior mediastinum, the left vagus lies first behind the left common carotid artery and behind the left phrenic nerve, which has crossed in front of it from left to right; and it is in front of the left subclavian artery. It then passes across the left side of the arch of the aorta ; and, in that situation, it is crossed laterally by the left superior intercostal vein. Having crossed the aortic arch, it passes to the back of the root of the left lung, where it breaks up into branches which enter into the formation of the posterior pulmonary plexus. At the lower border of the root of the left lung it emerges from the plexus as one or two trunks which descend into the posterior mediastinum, where they break up to form part of the *œsophageal plexus.*

Thoracic Branches of Left Vagus.—These branches are :—(1) the recurrent laryngeal ; (2) small branches to the pericardium that arise from the vagus as it crosses the arch of the aorta ; (3) branches to the bronchus and the lung through the pulmonary plexuses ; and (4) branches to the œsophagus and the pericardium through the œsophageal plexus.

The **left recurrent laryngeal nerve** springs from the left vagus on the left side of the aortic arch. It curves medially round the lower border of the arch behind the ligamentum arteriosum, and passes upwards, through the superior mediastinum, in the groove between the left border of the trachea and the œsophagus, and leaves the thorax at the inlet to pass into the neck. As it turns round the arch of the aorta, it gives branches to the deep cardiac plexus ; and, as it ascends along the trachea, it gives offsets to the trachea and to the œsophagus.

Pulmonary Plexuses.—The pulmonary plexuses lie one in the front of the root of the lung and one in the back of it. The branches that proceed from them supply the structures of the root and pass into the lung through the hilum to supply the pulmonary substance and pulmonary pleura.

The *anterior pulmonary plexus* is small. It is formed by filaments that arise from the vagus above the root and by branches from the deep cardiac plexus (and, in the case of the left plexus, from the superficial cardiac plexus also).

The *posterior pulmonary plexus* is much larger, for it is formed by the vagus breaking up into a network, and it receives branches also from the second, third and fourth thoracic ganglia of the sympathetic trunk. The right and left posterior plexuses are connected together by fairly thick cords that were found crossing the œsophagus—both in front of it and behind it—when the root of the lung was dissected (p. 51).

Œsophageal Plexus.—This is a network of nerves formed around the part of the œsophagus that lies in the posterior mediastinum. It is composed of branches of both vagi, for, when the vagi emerge from the posterior pulmonary plexuses and pass into the posterior mediastinum, they break up again into branches which unite together around the œsophagus and form the plexus. The plexus receives a contribution from the sympathetic system in the form of a few filaments from the greater splanchnic nerve of each side.

Fibres of both vagi pass from the plexus to the pericardium and the right and left parietal pleura and to the œsophagus ; and the cords of the lowest part of the plexus unite together to form trunks called the *anterior* and *posterior gastric nerves.* These two nerves descend through the œsophageal opening of the diaphragm to the stomach ; they lie one on the front of the œsophagus and one on the back ; and each contains fibres of both vagi and a few sympathetic filaments.

Deep Cardiac Plexus.—The deep cardiac plexus lies on the lowest part of the trachea, hidden under cover of the anterior part of the arch of the aorta. It is formed by the interlacement of numerous slender cardiac nerves that come from both sympathetic trunks, both vagi and both recurrent

PLATE IX

FIG. 65.—Radiograph of right half of Thorax of man aged 36, after the injection of "lipiodol" into the Right Bronchus.

(Dr. J. F. Brailsford)

The branching of the bronchi of the upper and lower lobes of the Lung is well shown. Cf. Figs. 30 and 64.

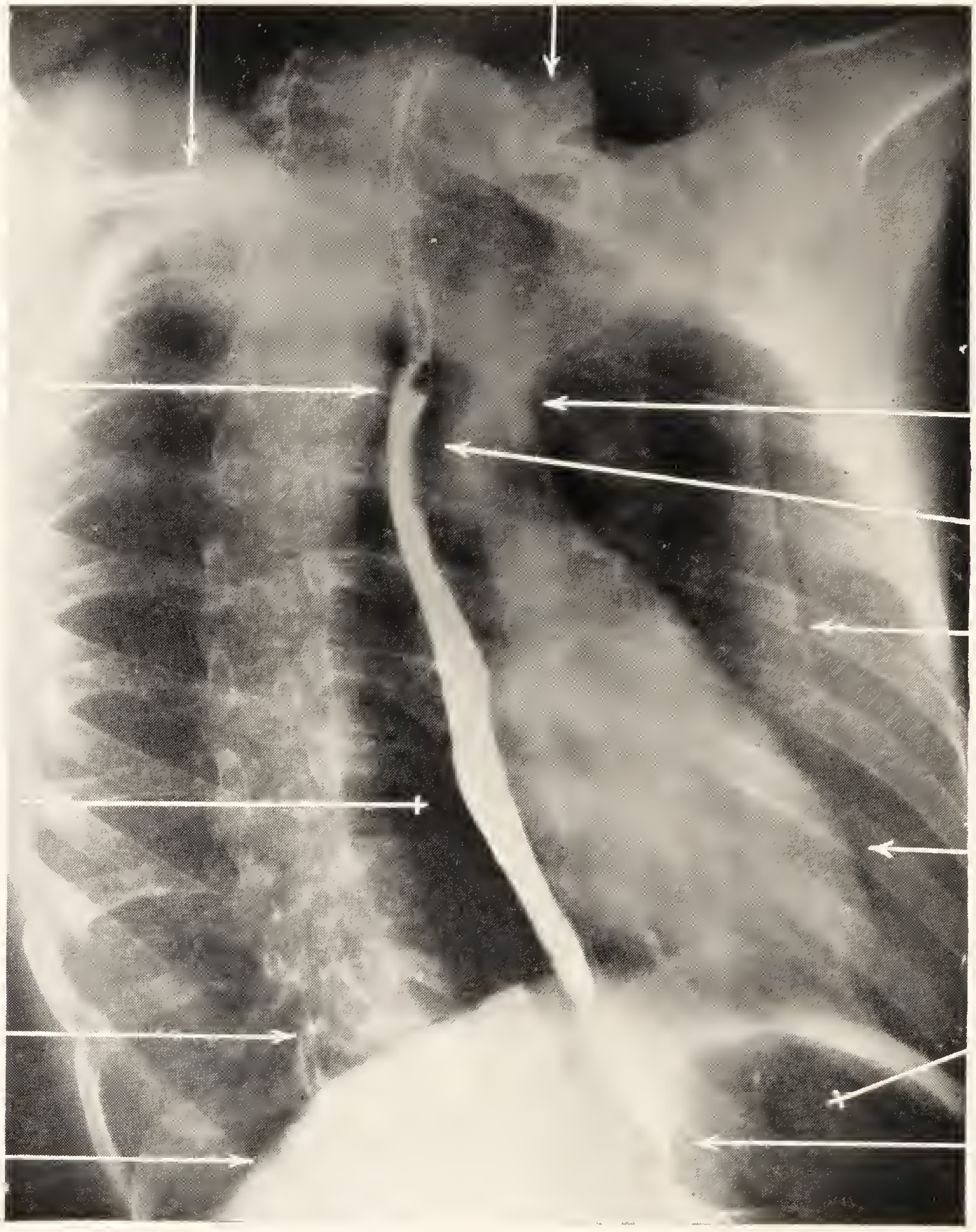


FIG. 66.—Oblique Lateral Radiograph of Thorax of youth aged 18, during passage of "barium paste" through Œsophagus. Cf. Figs. 32 and 35, and note that the post-cardiac space is part of the posterior mediastinum occupied mainly by the Œsophagus and the Descending Aorta. Compare also with the antero-posterior radiograph in Fig. 68.

laryngeal nerves ; and it receives communicating filaments from the superficial cardiac plexus.

Its branches are distributed (1) to the heart, partly directly to the atria and partly through the coronary plexuses (p. 83), and (2) to the lungs through the anterior pulmonary plexuses.

The *right half* of the plexus receives :—(1) cardiac branches from the three cervical ganglia of the right sympathetic trunk and cardiac branches from the second, third and fourth thoracic ganglia ; (2) the two cervical cardiac branches of the right vagus ; (3) the cardiac branch of the right recurrent laryngeal nerve ; (4) the thoracic cardiac branch of the right vagus. It gives branches to :—(1) the right anterior pulmonary plexus ; (2) the right atrium ; (3) the right coronary plexus.

The *left half* receives :—(1) the cardiac branches of the middle and lower cervical ganglia of the left sympathetic trunk and cardiac branches from the second, third and fourth thoracic ganglia ; (2) the upper cervical cardiac branch of the left vagus ; (3) the cardiac branches of the left recurrent laryngeal nerve ; (4) filaments from the superficial cardiac plexus. It gives branches to :—(1) the left anterior pulmonary plexus ; (2) the left atrium ; (3) the left coronary plexus.

***Dissection.*—To expose the thoracic part of the œsophagus, cut through the right and left bronchi close to their origin ; then, divide the trachea at the inlet of the thorax and remove its thoracic portion, but avoid injury to the vagi and the left recurrent laryngeal nerves. The extrapulmonary parts of the bronchi will be retained in position by the bronchial arteries and the branches of the pulmonary plexuses.**

Œsophagus.—The œsophagus begins in the neck, where it is continuous with the lower end of the pharynx. It descends through the lower part of the neck behind the trachea, and enters the thorax at the inlet ; it then descends through the superior and posterior mediastina, and leaves the thorax, opposite the seventh left cartilage about an inch from the median plane, at the level of the ninth thoracic spine, by passing through the œsophageal orifice of the diaphragm into the abdomen, where it joins the stomach almost at once. As it enters the thorax it is slightly to the left of the median plane, and trends more to the left as it descends (Fig. 68), till, about the level of the seventh thoracic vertebra, it begins to pass from the medial side of the descending aorta on to the front of it ; and, since the aorta, as it descends, inclines from the left side of the vertebral bodies towards the median plane, the œsophagus is even more to the left than the aorta before it pierces the diaphragm (Fig. 70). Note that the œsophagus is closely related to the aorta—first on its right side and then in front of it.

Examine Fig. 66 and note that in a lateral radiograph of the chest the posterior mediastinum appears as a "post-cardiac space" whose anterior part is occupied by the œsophagus (white) and the posterior part by the aorta (black)

Posterior Relations.—In the superior mediastinum, the longus cervicis muscles and the vertebral column are behind the œsophagus. It is separated from the vertebral column in the *upper part* of the *posterior mediastinum* by :—(1) the œsophageal plexus, (2) the upper five right aortic intercostal arteries, (3) the thoracic duct, (4) the vena azygos, (5) the hemiazygos veins; and in the *lower part* by (6) the œsophageal plexus and (7) the descending aorta.

Anterior Relations.—Anterior to it, *in the superior mediastinum*, there are the trachea, the left recurrent laryngeal nerve, and the structures which lie still farther forwards. *As it passes from the superior to the posterior mediastinum* its anterior relations are first the commencement of the left bronchus and then the right pulmonary artery. [Confirm this statement by replacing the heart *in situ*, and see also Figs. 50, 57.] *In the posterior mediastinum*, the œsophageal plexus is on its anterior surface, intervening between it and the posterior wall of the pericardium, which separates them from the left atrium; and, at a lower level, the diaphragm is in front of the œsophagus (Fig. 70).

Right Relations.—In the superior mediastinum, it is in relation with the right pleura and lung, and with the arch of the vena azygos (Fig. 17); and, *in the posterior mediastinum*, with the œsophageal plexus and right pleura and lung, until it passes forwards and towards the left on to the front of the descending aorta (Figs. 67, 70).

Left Relations.—In the superior mediastinum, it is in relation with the thoracic duct, the left subclavian artery, the left pleura and lung, and the arch of the aorta. *From the fifth to the seventh thoracic vertebra*, its left lateral relations are the œsophageal plexus and the descending aorta; *its lower part*, which lies in front of the descending aorta, is in relation with the left pleura and lung.

The dissector should note :—(1) that after death, the œsophagus is frequently relaxed (see Figs. 28 and 35), but is usually slightly compressed antero-posteriorly by the structures between which it lies; and (2) that it is slightly constricted at the level of the left bronchus and as it pierces the diaphragm.

The course of the œsophagus may be demonstrated by radiography after the passage of an instrument which is opaque to X-rays; but a more natural view is obtained after the swallowing of "barium paste," because it passes slowly and smears the mucous coat with an opaque lining (Figs. 66, 68).

Structure of Œsophagus.—Remove an inch or more of the upper part of the thoracic portion of the tube and dissect it under water in a cork-lined tray. It will be found to possess the following coats from without inwards:—(1) a sheath of fibrous tissue; (2) a muscular coat; (3) a submucous coat of areolar tissue; and (4) a lining of mucous membrane. The submucous coat connects the muscular and mucous coats loosely so that, when the muscular coat is contracted, the mucous lining is thrown into longitudinal folds. The muscular coat consists of an external layer of longitudinal fibres and an internal layer of circular fibres.

Descending Aorta.—The descending aorta is continuous with the arch at the lower border of the left side of the fourth thoracic vertebra. It descends through the posterior mediastinum, inclining to the right and forwards from the left side of the vertebral bodies on to the front of them; and it leaves the thorax by passing through the aortic opening of the diaphragm, opposite the lower border of the twelfth thoracic vertebra in the median plane. Its length varies with the length of the thorax but averages from seven to eight inches (Figs. 25, 37, 50, 57, 69).

Branches.—Branches spring both from the front and from the back of the descending thoracic aorta Those from the front are:—(1) two left *bronchial* arteries (pp. 51, 56), (2) four *œsophageal* branches which pass at once into the œsophagus; and (3) some small and irregular *mediastinal*, *phrenic* and *pericardial* branches which are distributed respectively to the lymph-glands and fat in the posterior mediastinum, to the posterior part of the diaphragm, and to the back of the pericardium. The posterior branches are nine pairs of posterior *intercostal* arteries for the lower nine spaces and one pair of *subcostal* arteries (p. 127).

Relations.—*Anterior* to the descending thoracic aorta, from above downwards, there are:—(1) the root of the left lung; (2) the pericardium, separating the aorta from the left atrium; (3) the œsophagus and œsophageal plexus, separating the aorta from the lower part of the pericardium ; and (4) the diaphragm, which separates the lower part of the thoracic aorta from structures in the abdomen—viz., a part of the lesser sac of peritoneum, and, in front of that, a part of the back of the liver called its caudate lobe (Fig. 35). *Posteriorly*, there are the vertebral column, its own intercostal and subcostal branches, and the hemiazygos veins ; and it is overlapped posteriorly in its upper part by the left pleura and lung.

Along its right side, in its whole length, there are the thoracic duct and the vena azygos—with the œsophagus in front of them from the fifth thoracic vertebra to the lower part of the

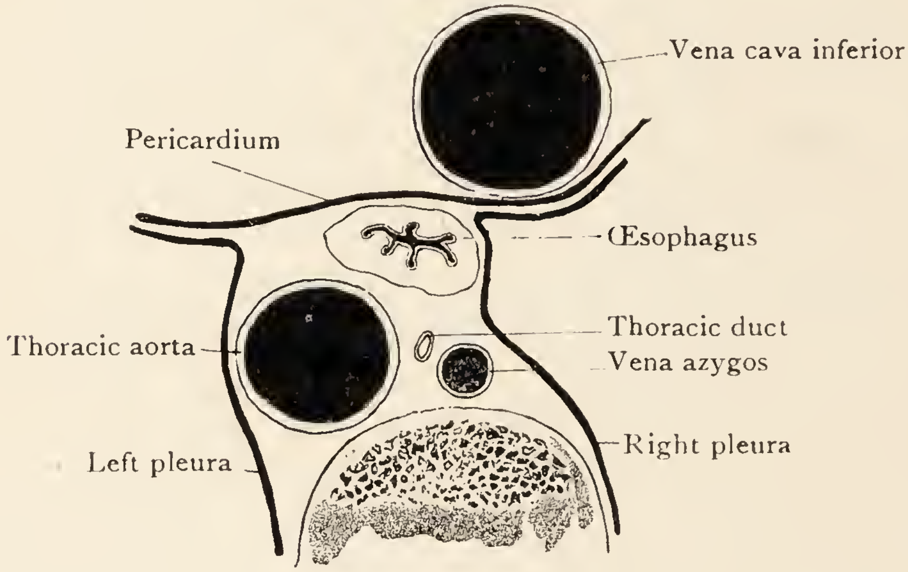


Fig. 67.—Tracing of Section through Posterior Mediastinum at the level of the eighth thoracic vertebra.

seventh. At a lower level, the right pleura may be in contact with it or may be separated by a mass of fatty areolar tissue. *On its left side* it is in relation with the left pleura and lung.

> ***Dissection.***—The œsophagus has already been divided in the superior mediastinum. Turn the lower part downwards towards the diaphragm. Clean the *thoracic duct*, the *right posterior intercostal arteries*, and the *hemiazygos veins*. Then, trace the thoracic duct upwards through the thorax, and arrange with the dissectors of the Head and Neck to display the cervical portion of its course.

Thoracic Duct.—The thoracic duct is a vessel of small calibre but of great importance ; for it conveys most of the lymph of the body to the blood-stream—including the lymph from the intestines. The intestinal lymph is called *chyle*, and its special importance is that it contains most of the fat

PLATE XI

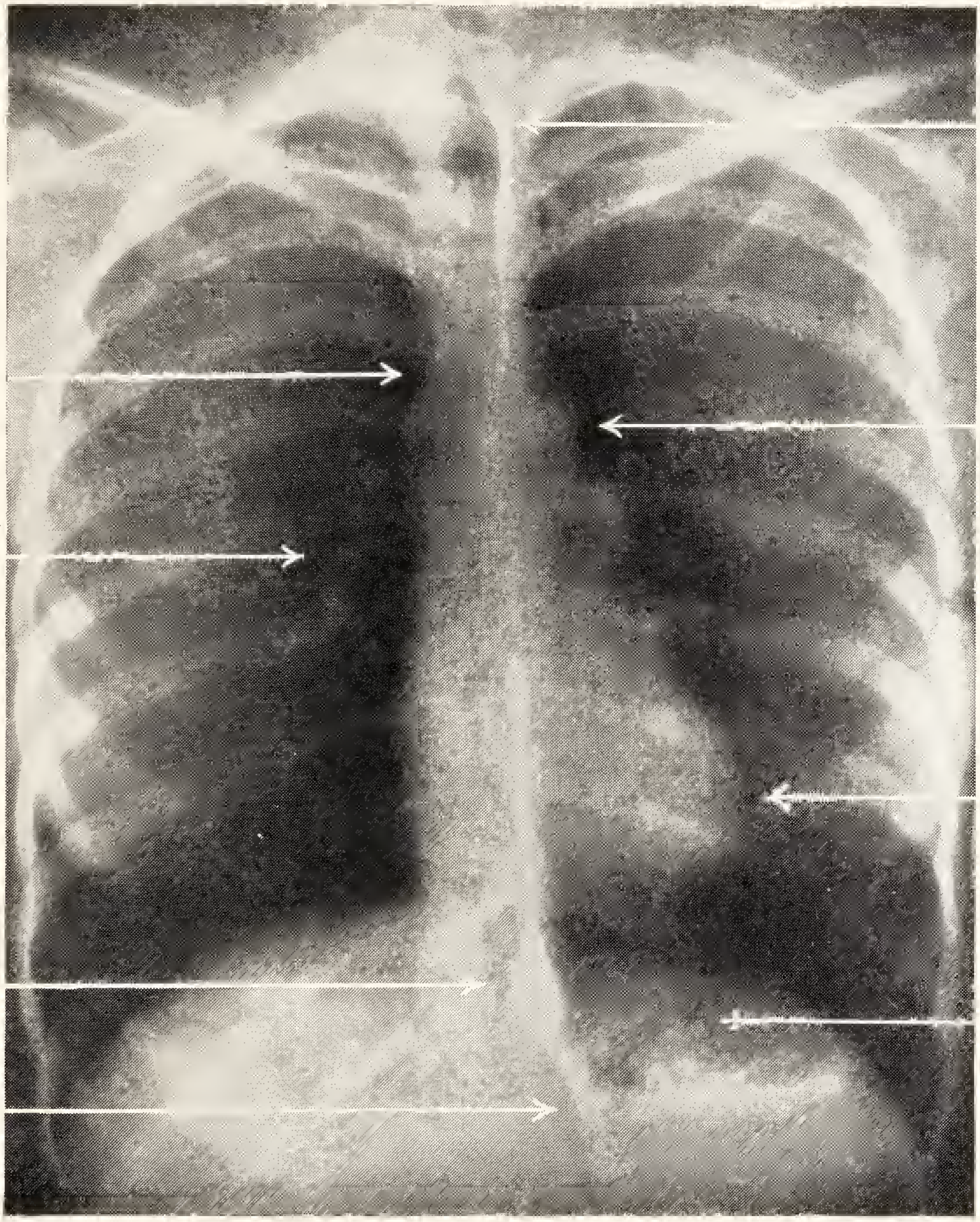
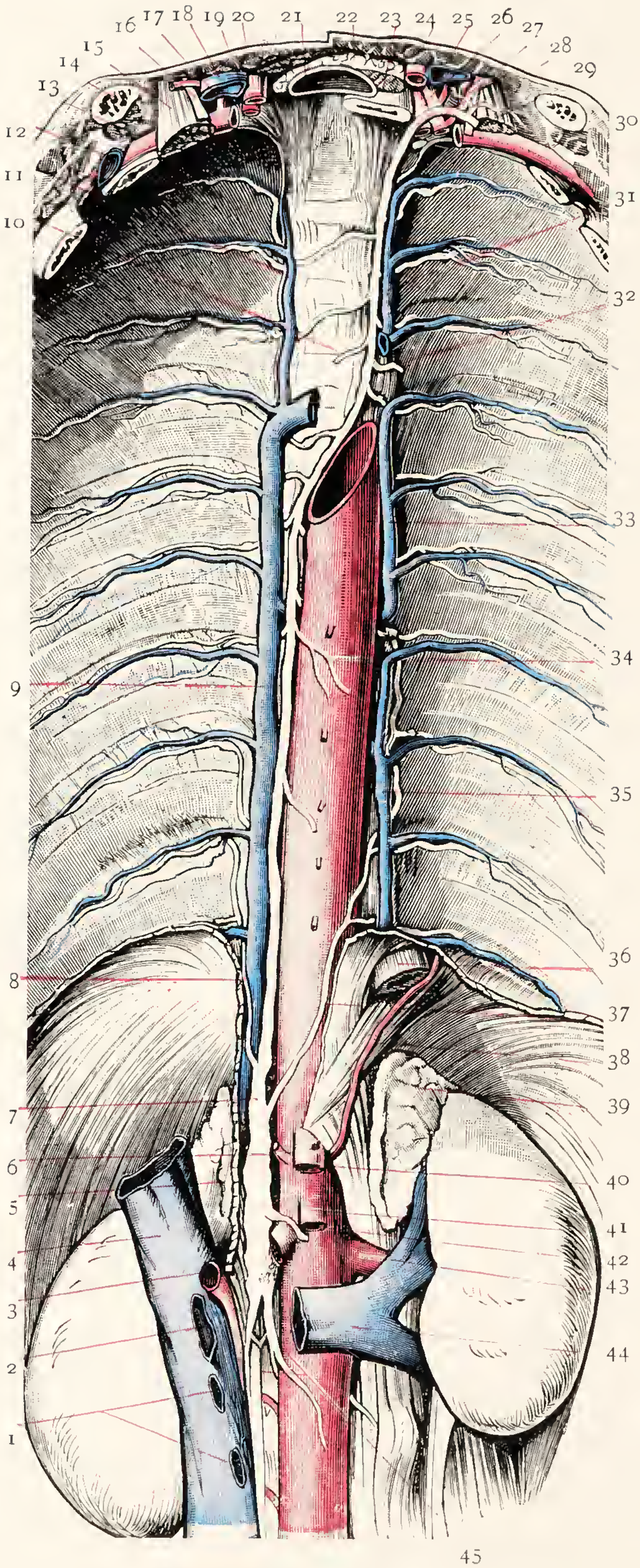


Fig. 68.—Antero-Posterior Radiograph of Thorax during passage of "barium paste" through Œsophagus (Dr. R. McWhirter).

Note the delay of the barium in the lower end of the Œsophagus, its passage through the Cardiac Orifice and along the Lesser Curvature of the Stomach, and the fact that some of it has spread out horizontally below the gas in the Fundus. Compare with the oblique lateral radiograph in Fig. 66.

Note also the deviation of the Œsophagus in relation to the Arch of the Aorta ; and for the relation of structures in that region see Figs. 58 and 64.



1. Lumbar veins.
2. Left renal vein.
3. Right renal artery.
4. Inferior vena cava.
5. Suprarenal gland.
6. Cisterna chyli.
7. Thoracic duct.
8. Descending thoracic lymph-trunk.
9. Vena azygos.
10. Mediastinal lymph-vessel.
11. Superior intercostal vein.
12. Subclavian vein.
13. Subclavian artery.
14. Clavicle.
15. Scalenus anterior.
16. Phrenic nerve.
17. Thyro-cervical trunk.
18. Internal jugular vein.
19. Vertebral artery.
20. Common carotid artery.
21. Trachea.
22. Thyroid gland.
23. Œsophagus.
24. Common carotid artery.
25. Internal jugular vein.
26. Vertebral artery.
27. Thyro-cervical trunk.
28. Junction of jugular and subclavian lymph-trunks.
29. Scalenus anterior.
30. Subclavian artery.
31. Superior intercostal vein.
32. Mediastinal lymph-vessel.
33. Sup. hemiazygos vein.
34. Aorta.
35. Inf. hemiazygos vein.
36. Œsophagus.
37. Descending thoracic lymph-trunk.
38. Phrenic artery.
39. Suprarenal gland.
40. Cœliac artery.
41. Sup. mesenteric art.
42. Intestinal lymph-trunk.
43. Left renal artery
44. Left renal vein.
45. Lumbar lymph-trunks.

FIG. 69.—Thoracic Duct and its Tributaries.

[*Facing p.* 123

absorbed from the food ; it is owing to the fat that the contents of the thoracic duct are milky in appearance after a meal.

Origin, *Course*, *Relations*, and *Termination*.—The thoracic duct arises in the abdomen from an elongated sac, called the *cisterna chyli*, which lies on the first and second lumbar vertebræ under cover of the right crus of the diaphragm. It enters the thorax through the aortic opening of the diaphragm, lying between the aorta on the left and the vena azygos on the right. It continues upwards through the posterior mediastinum, lying between the descending aorta and the vena

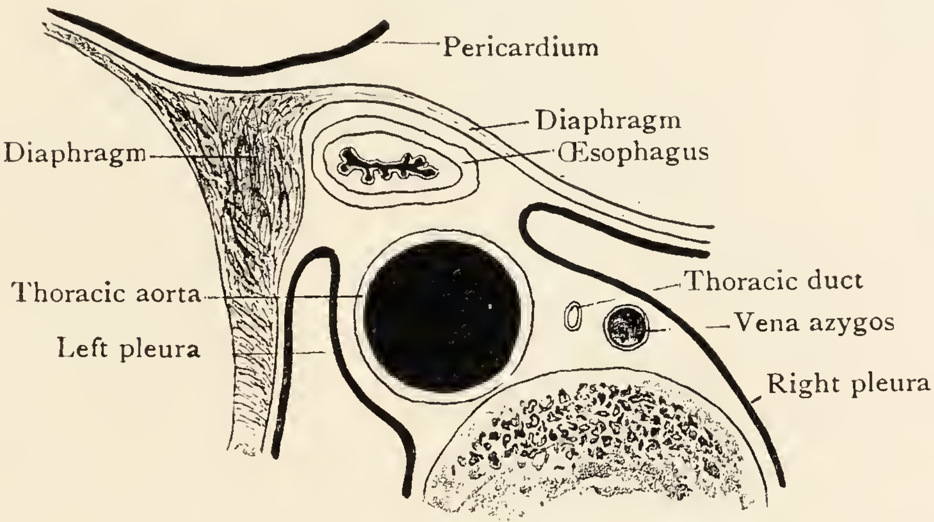


FIG. 70.—Tracing of Section through lower part of Posterior Mediastinum, where its anterior wall is formed by the diaphragm.

azygos, in front of the right posterior intercostal arteries and the transverse parts of the hemiazygos veins, at first behind the diaphragm and then behind the œsophagus. At the level of the fifth thoracic vertebra it crosses to the left of the median plane; and it then ascends, through the superior mediastinum, along the left border of the œsophagus, in contact, on the left, first with the aortic arch and then with the left pleura. At the inlet of the thorax the thoracic duct enters the root of the neck, where it arches laterally behind the left carotid sheath, and then downwards in front of the subclavian artery to terminate in the upper end of the left innominate vein, in the angle of junction of the internal jugular and subclavian veins (Fig. 71).

The duct may divide and re-unite in its course through the thorax, and in the superior mediastinum it frequently communicates with the right mediastinal lymph-trunk. When it is distended, it has a beaded appearance on account of the numerous valves in its interior. The terminal valve is usually situated a short distance from the end of the duct.

Tributaries.—By means of its tributaries the thoracic duct draws the lymph from both halves of the body below the diaphragm and the left half above the diaphragm. The exceptions to this generalisation are indicated in the following list. It receives the lymph from :—(1) the lower limbs ; (2) the abdomen, except that from part of the upper portion of the liver ; (3) the left side of the thorax (including left lung and pleura, and the left side of the heart) ; (4) the posterior part of the thoracic wall (including parietal pleura) of the right side ; (5) part of the posterior mediastinum (including the œsophagus and the back of the pericardium) ; (6) the left upper limb ; and (7) the left side of the head and neck.

Immediately before its termination it usually receives the united *left jugular* and *subclavian lymph-trunks* (which convey lymph from the left side of the head and neck and from the left upper limb, respectively), unless they end separately in one or other of the three large veins. It may also—though rarely—receive the *left mediastinal lymph-trunk.* This trunk collects lymph from the deeper parts of the anterior thoracic wall and of the upper part of the anterior abdominal wall and from the anterior part of the diaphragm on the left side, from the left half of the mediastinum, the left side of the heart and the left lung ; and, as a rule, it enters separately into the commencement of the left innominate vein.

Right Lymphatic Duct.—This vessel rarely exists as such; since the three vessels which occasionally unite to form it usually open separately into the right internal jugular, subclavian, and innominate veins. These three vessels are the *right jugular*, the *right subclavian*, and the *right mediastinal lymph-trunks.* It is not uncommon for the jugular and subclavian trunks (conveying lymph from the right side of the head and neck and from the right upper limb respectively) to unite, as on the left side, before entering the veins at the point corresponding to that at which the thoracic duct enters on the left side ; and this is the commonest form of "right lymphatic duct."

Right Mediastinal Trunk.—This trunk collects lymph from an area corresponding to that drained by the left vessel, but including also the upper part of the right lobe of the liver. It almost invariably enters the right innominate vein separately ; but even in the rare event of its union with the other two trunks the resulting *right lymphatic duct* does not correspond to the thoracic duct but only to the united tributaries which the thoracic duct also receives.

Lymph-Glands of Thorax.—During the dissection of the thorax the dissectors will have noted certain groups of lymph-glands. These are of considerable importance, for their enlargement in disease is not infrequently the cause of serious thoracic trouble ; but whilst some, such as the tracheo-bronchial and broncho-pulmonary glands, are quite obvious, others are frequently so small that they escape notice.

The following are the chief groups :—(1) A pair of chains of minute glands placed in relation to the anterior thoracic wall along the course

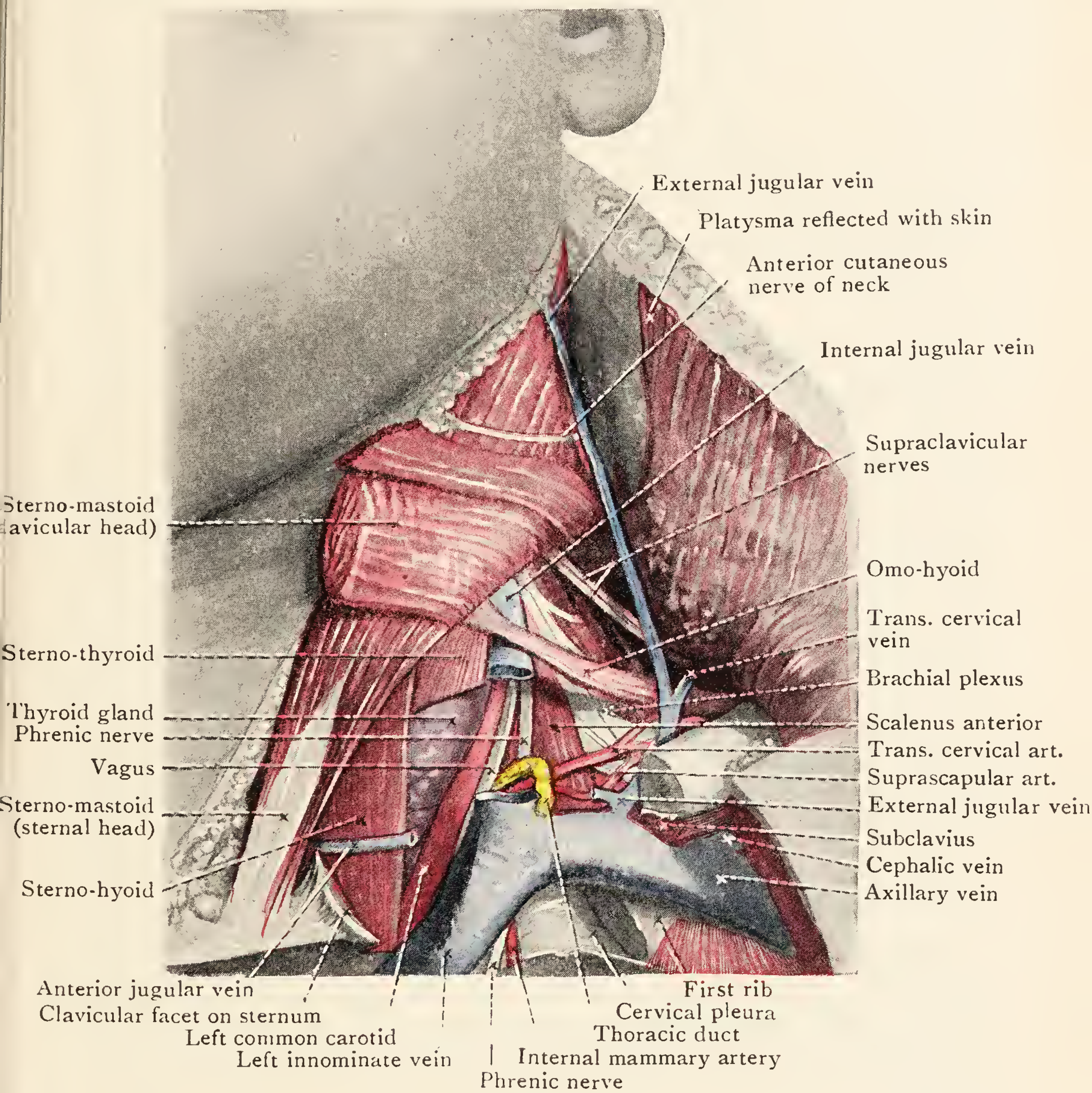


FIG. 71.—Dissection of Root of Neck showing the termination of Thoracic Duct.

of the internal mammary vessels, and therefore named *internal mammary lymph-glands*. They are joined by deep lymph-vessels from the anterior thoracic wall, the anterior part of the diaphragm, and the upper part of the anterior wall of the abdomen ; lymph-vessels from the medial part of the mammary gland also reach them through the anterior ends of the intercostal spaces (see Vol. I, p. 28).

(2) A pair of chains of minute glands in relation to the posterior parts

of the intercostal spaces and the vertebral ends of the ribs. They are called the *intercostal lymph-glands*, and receive the lymph-vessels of the posterior thoracic wall.

(3) Four or five *diaphragmatic lymph-glands* receive lymph from the diaphragm and upper surface of the liver. They lie on the thoracic surface of the diaphragm near its anterior attachments and near the phrenic nerve as it pierces the diaphragm.

(4) *Posterior mediastinal lymph-glands* lie along the descending thoracic aorta, and are joined by lymph-vessels from the diaphragm, pericardium and œsophagus.

(5) *Tracheo-bronchial lymph-glands* are associated with the intra-thoracic part of the trachea and the extrapulmonary parts of the bronchi; the lower glands of this group lie on and below the bifurcation of the trachea.

(6) *Broncho-pulmonary lymph-glands*, which lie in the hilum of the lung and in the angles of division of the bronchi in the substance of the lung.

(7) *Innominate lymph-glands*, an important group, eight to ten in number, placed in relation to the left innominate vein. They receive lymph from the heart, the pericardium, and the thymus.

The *mediastinal lymph-trunk* is formed, on each side, by the union of the efferent lymph-vessels from the internal mammary, the tracheo-bronchial and the innominate lymph-glands; and the lymph from the lungs and the visceral pleura passes through the broncho-pulmonary and tracheo-bronchial glands on its way to reach this main vessel. As the lymph traverses the glands, the carbon particles, which have passed from the air in the pulmonary alveoli through the walls of the alveoli and the walls of the lymph-capillaries into the lymph, are deposited in the lymphoid substance and in the stroma of the lymph-glands, which, as a consequence, gradually become blacker and blacker as life continues.

The dissectors will now complete the study of the intercostal nerves and the posterior intercostal vessels by examining the parts of them that lie in the posterior wall of the thorax.

Dissection.—The *intercostal vessels* have been partly cleaned already. Complete the cleaning of them; and clean also the *intercostal nerves* and the *hemiazygos* veins.

Posterior Intercostal Arteries.—There are eleven pairs of posterior intercostal arteries. The upper two pairs are derived indirectly from the subclavian arteries; the remaining nine pairs are branches of the descending thoracic aorta.

The *superior intercostal artery*, whose branches supply the upper two intercostal spaces, is derived from the costo-cervical trunk of the subclavian artery. It arises from that trunk at the upper border of the neck of the first rib. It descends in front of the neck of the rib, behind the pleura, lateral to the sympathetic trunk, and medial to the first thoracic nerve, which is passing upwards to the brachial plexus (Fig. 9). At the lower border of the neck of the first rib, it gives off the *posterior intercostal artery* (*I*) to the first intercostal space ; it then crosses the front of the neck of the second rib, and, turning laterally, it becomes the *posterior intercostal artery* (*II*) of the second space.

The lower nine pairs of *posterior intercostal arteries* (III-XI) spring from the back of the descending aorta—usually separately, but occasionally a pair may arise by a common trunk. The right arteries are longer than the left because the aorta lies to the left of the median plane ; and, since the descending aorta begins only at the level of the lower border of the fourth thoracic vertebra, the four or five highest pairs have to ascend to gain the level of the spaces in which they are distributed (Figs. 17 and 18).

The *right posterior intercostal arteries* cross in front of the bodies of the vertebræ, behind the thoracic duct and the vena azygos ; they then turn backwards, between the sides of the bodies of the vertebræ and the parietal pleura, where the lower ones are crossed by the greater splanchnic nerve and its roots ; and, finally, immediately before they enter the intercostal spaces, they pass behind the sympathetic trunk.

The *left intercostal arteries* run backwards between the left pleura and the bodies of the vertebræ, and are crossed superficially by the hemiazygos veins, by the greater splanchnic nerve and its roots, and by the sympathetic trunk.

As each artery enters its space it crosses in front of the intercostal nerve to take up its position above the nerve ; and, at this point, it gives off a posterior branch.

The *posterior branch* passes backwards, between the vertebral column and a superior costo-transverse ligament, giving off a *spinal twig* which enters the vertebral canal through the corresponding intervertebral foramen ; it then accompanies the posterior primary ramus of the corresponding thoracic nerve and ends in muscular and cutaneous branches.

After giving off the posterior branch, the trunk of the artery runs laterally, in the posterior part of the intercostal space between the posterior intercostal membrane and the pleura, with its companion vein above it and the nerve below it ; near the angle of the rib it disappears with them between the intercostal muscles. Its further course has been described already (p. 12).

Subcostal Arteries.—The subcostal arteries are the last pair of branches which spring from the back of the descending thoracic aorta. Each enters the abdomen by passing behind the lateral arcuate ligament of the diaphragm; and it runs, in company with the subcostal nerve, along the lower border of the last rib in the wall of the abdomen (see p. 396).

Intercostal Nerves.—The intercostal nerves are the anterior primary rami of the upper eleven thoracic nerves; they pass laterally in company with the arteries. The rami communicantes which connect them with the sympathetic ganglia have been noted already (p. 36). Each nerve lies at a lower level than the corresponding artery, and is placed, at first, between the posterior intercostal membrane and the pleura, and then between the muscular strata. The positions occupied by the majority of the thoracic nerves and their general distribution have already been described (see p. 10) but the first, second, and last nerves of the thoracic region require special consideration.

The anterior primary ramus of the first thoracic nerve is a thick bundle, the main part of which passes upwards and laterally across the front of the neck of the first rib to join the brachial plexus. The *first intercostal nerve*, in conformity with the size of the first space, is a small part of the bundle. It runs along the pleural surface of the first rib and enters the space near the costal cartilage (Fig. 9).

The *second intercostal nerve*, as a rule, sends a branch upwards, in front of the neck of the second rib, to join that portion of the first thoracic nerve which enters the brachial plexus. This communicating twig is usually insignificant; but sometimes it is a large nerve, and the intercosto-brachial nerve (*i.e.* the lateral cutaneous branch of the second intercostal nerve), which supplies skin in the upper limb, is then very small or altogether absent.

Subcostal Nerve.—This is the anterior primary ramus of the twelfth thoracic nerve. It is distributed to the wall of the abdomen and to the skin of the gluteal region. It emerges from the vertebral canal between the last thoracic and the first lumbar vertebræ, and passes almost at once from the thorax into the abdomen behind the lateral arcuate ligament (see p. 392), accompanying the subcostal artery.

Posterior Intercostal Veins.—These veins differ in their arrangement on the two sides of the body.

On the *right side* they terminate in three different ways :—

1. The *first posterior intercostal vein* ascends from the first space across the neck of the first rib alongside the superior intercostal artery, and then arches forwards over the pleura to join the *right innominate vein* (sometimes the *vertebral vein*) in the neck.
2. The veins of the second and third spaces (and sometimes a branch from the vein of the fourth space) unite to form the *right superior intercostal vein,* which joins the upper part of the *vena azygos.*
3. The veins of the lower eight spaces join the *vena azygos.*

On the *left side* there are four modes of termination :—

1. The *first posterior intercostal vein* resembles that of the right side.
2. The veins of the second and third spaces (and sometimes a contribution from the fourth vein) converge to form the *left superior intercostal vein,* which crosses the arch of the aorta and joins the *left innominate vein* in the thorax. It usually communicates with the superior hemiazygos vein, and may end wholly in it.
3. The veins of the fourth, fifth, sixth, seventh, and eighth spaces terminate in the *superior hemiazygos vein.*
4. The veins of the ninth, tenth, and eleventh spaces join the *inferior hemiazygos vein.*

The **azygos vein** has already been studied, but should now be revised (p. 37). The dissectors should then examine the hemiazygos veins.

Hemiazygos Veins.—The **superior hemiazygos vein** begins as a continuation of the fourth left posterior intercostal vein ; and, as it runs downwards over the vertebral bodies along the left side of the descending aorta, it is joined by the veins of the fifth, sixth, seventh, and eighth spaces. It communicates above with the left superior intercostal vein ; and it receives the left bronchial veins. At the level of the eighth thoracic vertebra it crosses to the right, behind the aorta and thoracic duct, to end by joining either the inferior hemiazygos vein or the vena azygos. It is very inconstant as regards both its tributaries and its termination.

The **inferior hemiazygos vein** takes origin within the abdomen from the back of the left renal vein. It enters the thorax by piercing the left crus of the diaphragm, and is continued upwards, on the vertebral column, close by the left side of the aorta, as far as the ninth or the eighth thoracic vertebra. At that level it turns to the right, crosses behind the aorta and the thoracic duct, and joins the vena azygos. Before it terminates it may receive the superior hemiazygos vein.

The thoracic tributaries of this vein are the posterior intercostal veins of the lower three spaces of the left side and the left subcostal vein. In the abdomen it may receive the upper two left lumbar veins.

Occasionally the abdominal parts of the azygos and inferior hemiazygos veins are absent. Each of them then begins on the side of the twelfth thoracic vertebra by the union of the subcostal vein and the ascending lumbar vein, which runs upwards across the front of the transverse processes of the lumbar vertebræ.

JOINTS OF THORAX

The dissector should now complete the dissection of the thorax by an examination of the various thoracic joints.

Dissection.—When the portion of the sternum, with the cartilages of the ribs, which was laid aside, is studied, the following joints will be noted : *sternal*, *sterno-costal*, and *inter-chondral*. Very little dissection is necessary. After the ligaments have been defined, remove a thin slice from the front of each joint to display its interior.

Sternal Joints.—The *manubrio-sternal joint* unites the manubrium to the body of the sternum, and is of the secondary cartilaginous type. The opposing surfaces of bone are united by an intervening plate of fibro-cartilage. The union is strengthened on the front and the back by longitudinal fibres developed in the periosteum, which is very thick and strong. The posterior ligament is the stronger of the two. The functional importance of this joint in respiration is indicated by the fact that it is seldom obliterated even in old age ; for it is of the secondary cartilaginous type, whereas the joints between the segments of the body of the sternum, being primary cartilaginous joints, unite by synostosis during childhood and adolescence.

The body of the sternum and the xiphoid process are united by the *xiphi-sternal joint*, which is cartilaginous till middle life, at which period the two parts usually become ossified together.

Sterno-Costal Joints.—Seven pairs of ribs articulate with the margins of the sternum by means of their cartilages. With the exception of the first, which is cartilaginous, the sterno-chondral joints belong to the synovial variety. They are provided with articular capsules, and also with intra-articular ligaments in those joints which have a double synovial cavity.

The first and the sixth joints are peculiar inasmuch as they articulate with single pieces of the sternum, viz., with the manubrium and the lowest piece of the body, respectively; whereas each of the cartilages of the other true ribs articulates with two segments of the sternum.

The cartilage of the first rib is implanted on the side of the manubrium; there is no synovial cavity and the union is effected by direct continuity of the cartilage and the bone and by the continuity of the perichondrium and the periosteum. The second costal cartilage is separated from the sternum usually by two synovial cavities—an upper and a lower—separated by an intra-articular ligament. In the other joints, it is more common to find a single cavity and no intra-articular ligament. There is, however, considerable variety in these joints, and a synovial membrane is very frequently wanting altogether in the joint between the seventh costal cartilage and the sternum. They are often obliterated in old age.

The *articular capsules* are stronger in front and behind, for strongly developed strands radiate from the front and back of the sternal ends of the costal cartilages (second to sixth inclusive) to the front and back of the sternum.

The *intra-articular* (*sterno-costal*) *ligaments* are feeble bands which attach the tips of some of the rib-cartilages to the sides of the sternum. They divide the cavities of the joints into compartments each of which is lined with synovial membrane.

Interchondral and Costo-Chondral Joints.—Small synovial joints, surrounded by ordinary articular capsules, are formed between the adjacent margins of the costal cartilages from the sixth to the ninth, but the tenth is united to the ninth by a fibrous joint. Each costal cartilage fits into a pit on the end of the bony part of the rib, and is held in place by the continuity of the periosteum and perichondrium.

Dissection.—Clean the ligaments that attach the ribs to the vertebral column. Remove the anterior part of the capsule of all the joints of the heads of the ribs of one side, and in each of them note the presence or absence of an intra-articular ligament. Then, remove the ribs entirely on the same side by cutting the intra-articular ligaments (where present), the remains of the capsules of the joints of the heads, the capsules of the costo-transverse joints and the costo-transverse ligaments. When this has been done, study the series of facets on the vertebral column and compare them with the facets on the dry bones.

Costo-Vertebral Joints.—These are the joints of the heads of the ribs and the costo-transverse joints.

The *joint of the head of the rib* is a synovial joint formed by the articulation of the head of the rib with the vertebral column. With the exception of the first rib and the last three

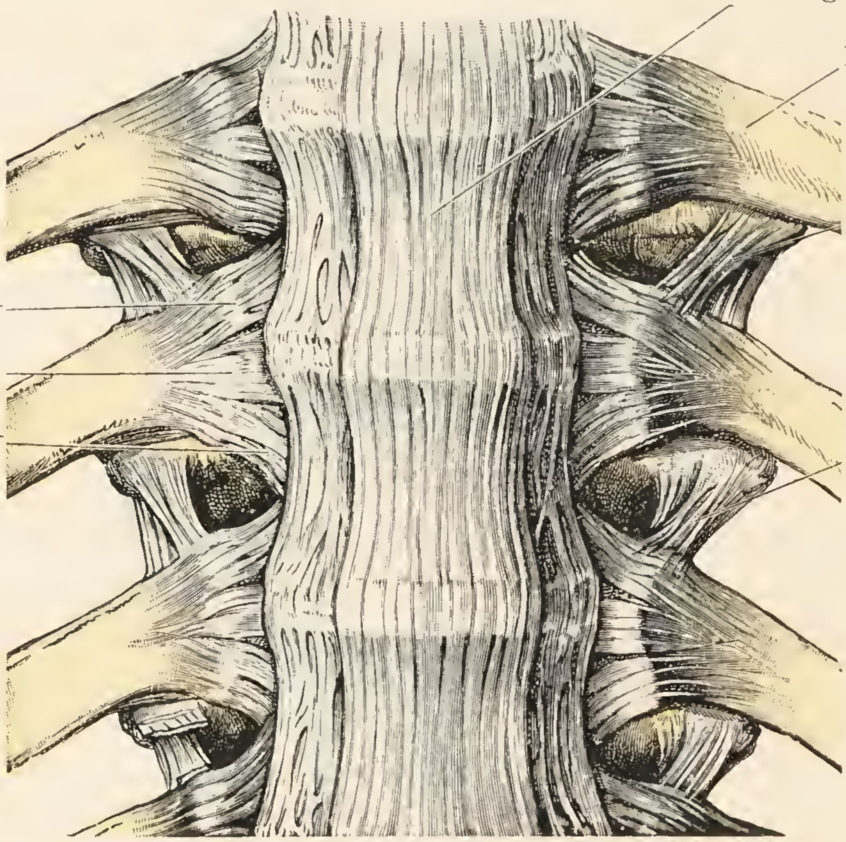


FIG. 72.—Anterior aspect of Costo-Vertebral Joints and of Anterior Longitudinal Ligament of Vertebral Column.

ribs, the head of every rib articulates with the bodies of two vertebræ and the intervening intervertebral disc, and it is connected with them by an articular capsule and an intra-articular ligament. The intra-articular ligament connects the intervertebral disc with the ridge which separates the two facets on the head of the rib. It is united, anteriorly and posteriorly, with the capsule, and divides the joint-cavity into an upper and a lower compartment. The anterior part of the capsule is specialised into three radiating bands which form the *radiate ligament*. The upper and lower bands go to the corresponding vertebræ, and the middle band is attached to the intervertebral disc. The joints of the first and of the tenth, eleventh, and twelfth ribs are each formed between the head of the rib and the corresponding vertebra. The intra-articular ligament is absent ; each joint possesses therefore only one cavity. The anterior parts of the capsules of those joints are not, as a rule, specialised into radiate bands.

In a *costo-transverse joint*, the neck and tubercle of the rib are connected with the transverse process of the vertebra of the same number and the transverse process next above.

The tubercle of each rib (with the exception of the eleventh and twelfth) articulates with the front of the tip of the transverse process of the vertebra of the same number by a circular articular facet which is surrounded by an articular capsule ; the joint is therefore a synovial joint. The postero-lateral part of the capsular ligament is greatly thickened to form the *lateral costo-transverse ligament*, which connects the rough, lateral part of the tubercle of the rib with the tip of the transverse process.

There are in addition two other costo-transverse ligaments —inferior and superior.

The *inferior costo-transverse ligament* connects the back of the neck of the rib with the front of the transverse process of the vertebra of the same number.

The *superior costo-transverse ligament* ascends from the upper border of the neck of the rib to the lower border of the transverse process above. Its anterior fibres pass obliquely upwards and laterally, and are continuous laterally with the posterior intercostal membrane ; its posterior fibres incline slightly medially and may reach the junction of the lamina and the transverse process of the vertebra above.

The costo-transverse ligaments are rudimentary or absent at the eleventh rib, and usually absent at the twelfth rib.

Movements of Ribs.—The principal movements of the true ribs are around two axes :—(1) An antero-posterior axis which passes through the sternum and the posterior part of the shaft of a rib. Rotating around this axis, each rib is raised—thus increasing the transverse diameters of the thorax. (2) An oblique axis which passes through the head, neck and tubercle of a rib. As the ribs rotate on this axis their anterior parts are raised, lifting up the sternum and thrusting its body forwards (which moves slightly at the manubrio-sternal joint), and thus increasing the antero-posterior diameters of the thorax. These movements are brought about by the intercostal muscles. Further details and explanations are to be found in the Text-books of Anatomy.

Joints and Ligaments of Vertebral Column.—The *bodies* of the vertebræ are held together by a series of secondary cartilaginous joints, supported by an anterior and a posterior longitudinal ligament. The *vertebral arches*, by means of the articular processes, form a series of synovial joints whose capsules are attached to the margins of the articular surfaces. Certain ligaments pass between different portions of the vertebral arches and their processes, viz., the ligamenta flava between adjacent laminæ, and the intertransverse, the interspinous, and the supraspinous ligaments.

When the dissectors of the Head and Neck opened into the vertebral canal, they removed the spines and laminæ of the vertebræ, but preserved them for the examination of the ligaments. After the joints of the vertebral bodies and transverse processes have been studied, join the dissectors of the Head and Neck in cleaning and examining these ligaments —if the Thorax is undergoing dissection at the same time as the Head and Neck. But, if the Thorax is an isolated part, ask leave of the dissectors of the Head and Neck of an adjoining body to study these ligaments on their specimen. In an isolated thorax, however, it may be that the vertebral column is intact. The dissectors will then proceed as follows :—

Dissection.—Remove all muscle-fibres from the spines and laminæ, and isolate them *in one piece* by sawing through the laminæ and cutting the ligamenta flava. Make the cut through the laminæ close to the medial side of the articular processes, and slant the saw slightly medially. In the lower part, a chisel and hammer may have to be used.

When the specimen is completely detached, stretch it to test the elasticity of the ligamenta flava, and then lay it aside until the longitudinal ligaments and intervertebral discs have been dissected and studied.

Dissection.—Clean the *longitudinal ligaments* on the anterior and posterior surfaces of the vertebral bodies, and the *capsules* of a few of the joints between articular processes.

The *anterior longitudinal ligament* lies on the front of the vertebral column, and extends from the atlas vertebra to the first piece of the sacrum. It consists of stout, glistening fibrous bands which are firmly attached to the margins of the vertebral bodies and to the intervertebral discs. The most superficial fibres are the longest, and extend from a given vertebra to the fourth or fifth below it. The deeper fibres have a shorter course, and pass between the borders of two or three adjacent vertebræ. The dissectors cannot fail to notice that the lower parts of the longus cervicis muscles are closely connected with the upper part of the thoracic portion of the ligament.

The *posterior longitudinal ligament* covers the backs of the vertebral bodies, and is therefore within the vertebral canal. It is firmly connected to the margins of the vertebral bodies and to the intervertebral discs, but is separated from the middle parts of the bodies by some loose areolar tissue and by a plexus of veins. It is narrow where it covers the venous plexus, but widens out opposite the discs. It therefore presents a scalloped or denticulated appearance.

Dissection. — Isolate the bodies of three or four vertebræ in one piece by making horizontal sections through two intervertebral discs that are some distance apart; remove the piece by dividing the capsules of the joints of the vertebral arches at each end. Then, section the piece sagittally with the saw in order to study the structure of the intervertebral discs.

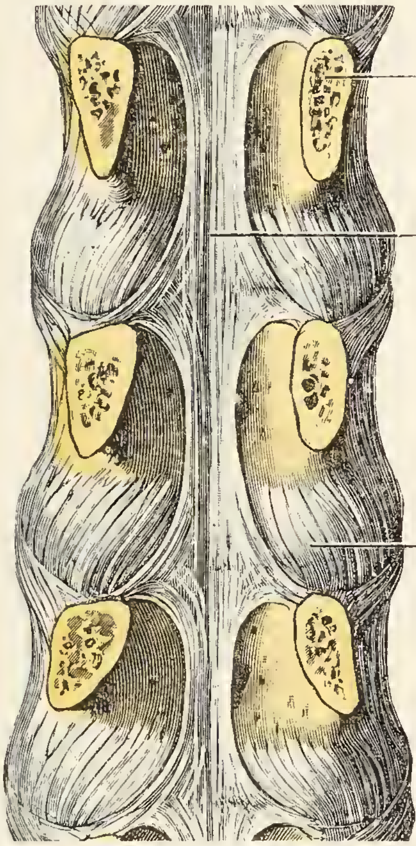


FIG. 73.—Posterior Longitudinal Ligament of Vertebral Column. The vertebral arches have been removed.

The *intervertebral discs* are a series of white fibro-cartilages interposed between the bodies of the vertebræ. In the thoracic region, they are thicker behind than in front. The peripheral part of each disc—the *annulus fibrosus*—is tough and fibrous; the central portion—the *nucleus pulposus*—is soft and pulpy, and is held under pressure by the surrounding tougher part. The discs increase the elasticity of the vertebral column, and tend to restore it to its natural curvature after it has been deflected by muscular action (Fig. 74).

The intervertebral discs constitute the main bond of union between the bodies of the vertebræ, but, except in old people, they are not attached directly to the bone, for a thin layer of hyaline cartilage coats the opposing vertebral surfaces.

When longitudinal sections of the vertebral bodies and intervening discs are examined, it is not uncommon to find small erosions of the encrusting hyaline cartilage and the underlying bone. Through these erosions "herniation" of the intervertebral disc takes place into the vertebral body, and the resulting diminution of pressure interferes with the proper functions of the nucleus pulposus (Schmorl).

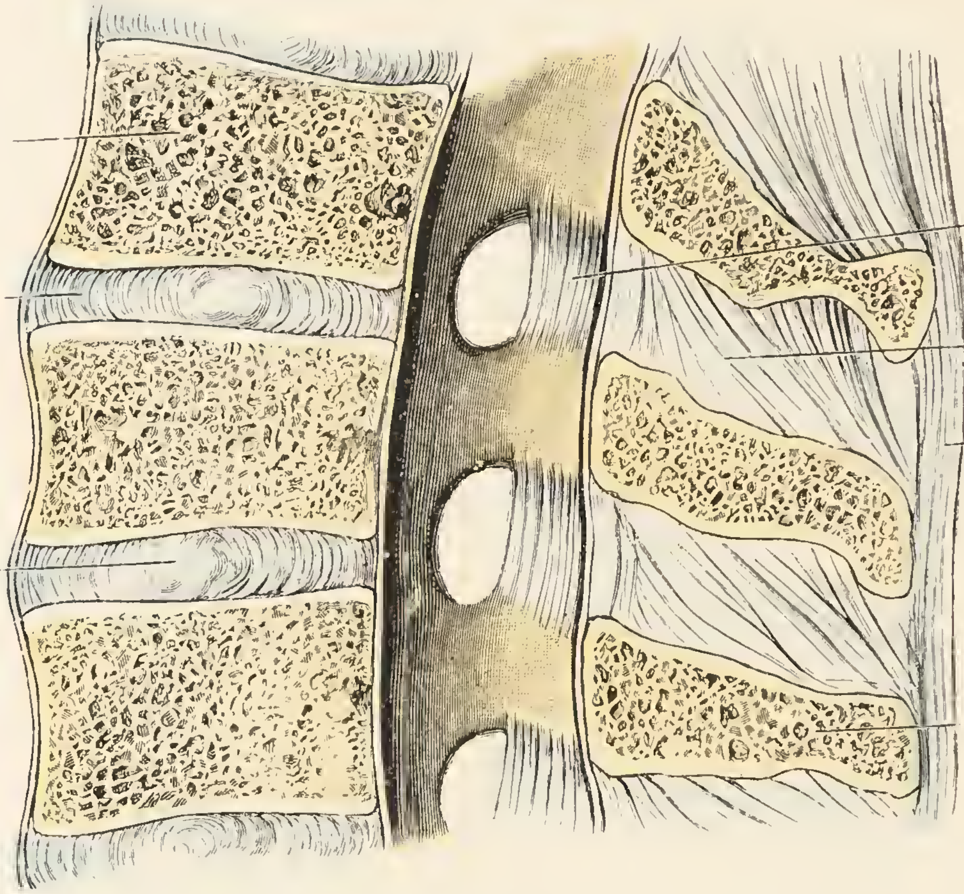


FIG. 74.—Median Section through a portion of Lumbar Part of Vertebral Column.

The *intertransverse ligaments* are feeble bands which pass between the tips of the transverse processes. In the lower part of the thoracic region they are intimately blended with the intertransverse muscles: in the middle and upper parts of the thoracic region they entirely replace those muscles.

At this stage, the dissectors either clean and study the ligaments of the spines and laminæ in the specimen removed by themselves, or join the dissectors of the Head and Neck in doing so on the specimen removed by them.

The *supraspinous ligaments* connect the tips of the spines; their deepest fibres pass from one spine to the next, but the superficial fibres connect spines that are some distance apart.

The *interspinous ligaments* fill the intervals between spines, and are weaker than those of the lumbar region, which are shown in Fig. 74.

The *ligamenta flava* are so named because of the yellowish tinge given to them by the elastic tissue which is mingled with the white fibrous tissue of their substance. They are pairs of flat bands that connect the laminæ; and, with the

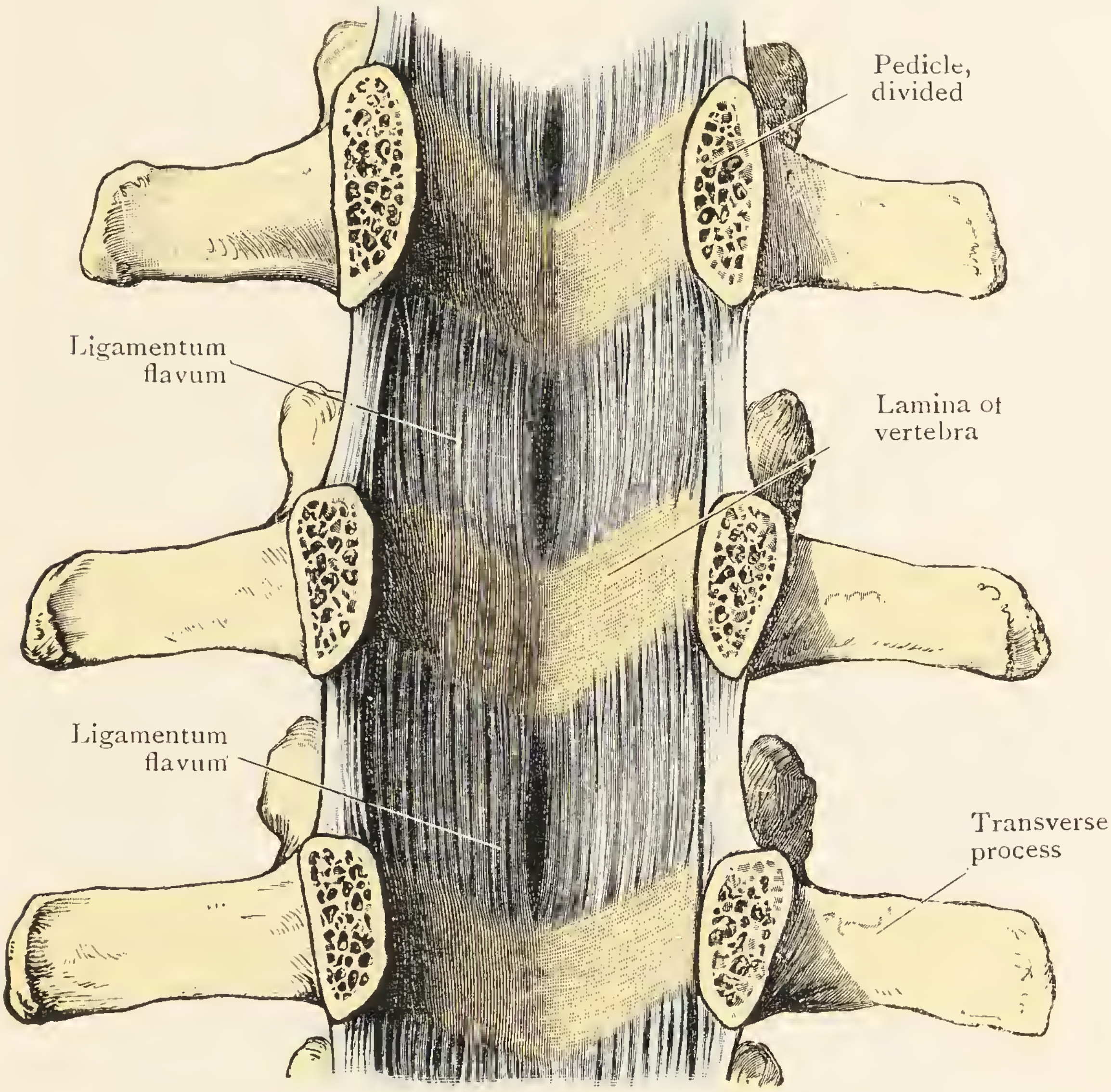


FIG. 75.—Ligamenta Flava in the Lumbar Region.

laminæ, they form a smooth posterior wall for the vertebral canal. Above and below, they are attached to the laminæ. Laterally, each one fuses with the capsule around the articular processes; medially, it falls a little short of the median plane and is separated from its fellow by an interval which is occupied by loose areolar tissue and transmits small blood-vessels.

ABDOMEN

When the body is brought into the dissecting-room, it is first placed in the "lithotomy position"; it is retained in that position for three days, during which time the dissectors of the Abdomen dissect the *perineum*.

PERINEUM

Boundaries of Perineum.—The perineum is the lower end of the trunk, and is situated between the lower part of the buttocks and between the thighs, extending from

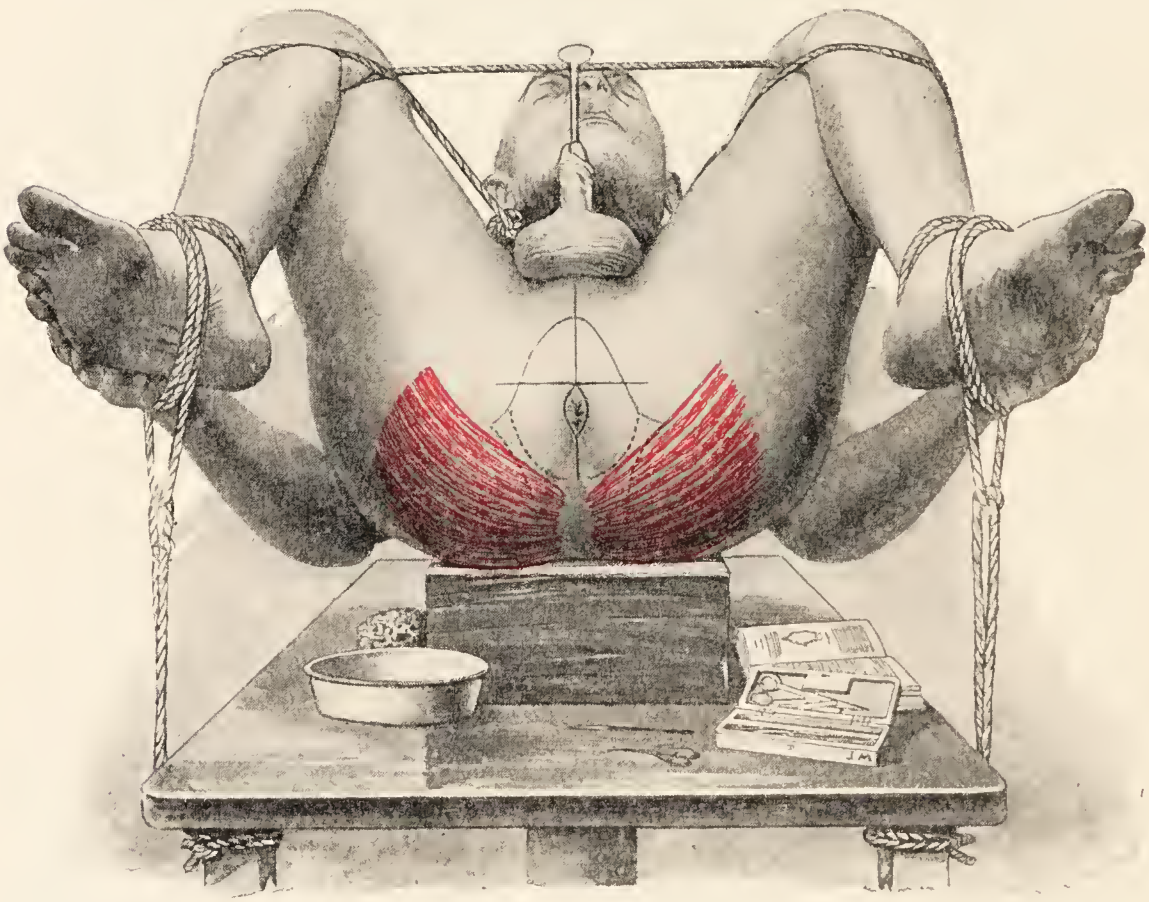


Fig. 76.—Body in "lithotomy position," showing the boundaries of the Perineum and the skin incisions. The position of the Gluteus Maximus is indicated in red.

the tip of the coccyx to the lower margin of the pubic symphysis. It corresponds with the outlet of the pelvis. It is therefore necessary that dissectors should renew their acquaintance with that part of the skeleton before they begin the dissection. Having obtained a pelvis with the ligaments *in situ*, they will note that the outlet of the pelvis is a diamond-shaped space which has the following boundaries :—*in front*, the pubic symphysis and the inferior pubic ligament ; *behind*, the coccyx ; and *on each side*, from before backwards, the rami of the pubis and ischium, the tuberosity of the ischium, and the sacro-tuberous ligament. If they now turn their attention to the body before them, they can readily identify the extent and limits of the space. The sacro-tuberous ligament, however, is obscured by the gluteus maximus muscle,

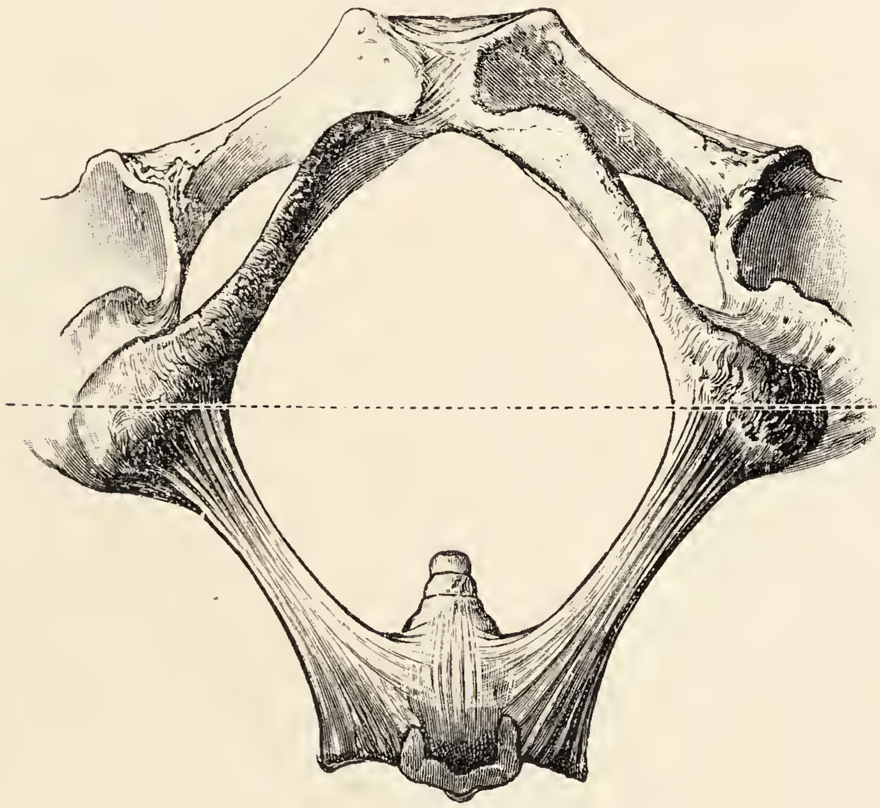


FIG. 77.—Outlet of Male Pelvis.

but it can be felt if firm pressure is made in a line between the ischial tuberosity and the coccyx.

The apparent superficial area of the perineum depends upon the posture of the body. When the thighs are extended and brought together, it is very limited : it is then merely a narrow groove which contains the anus, with the roots of the scrotum and penis in the male and the vulva in the female. The region is wider in the female than in the male, owing to the greater size of the pelvic outlet (Figs. 77, 78).

Division and External Anatomy of Perineum.—It is customary to divide the perineal space into two triangles by an imaginary transverse line drawn between the ischial tuberosities immediately in front of the anus. The anterior triangle is appropriately called the *urogenital triangle* because in the male it contains the urethra and the root of the penis, and, in the female, the urethral opening and the external genital organs; the posterior is known as the *anal triangle* because it contains the anal canal—which is the terminal inch and a half of the large intestine.

In the median line of the **male perineum**, a cutaneous ridge —the *median raphe of the perineum*—can be traced from the front of the anus forwards over the scrotum and along

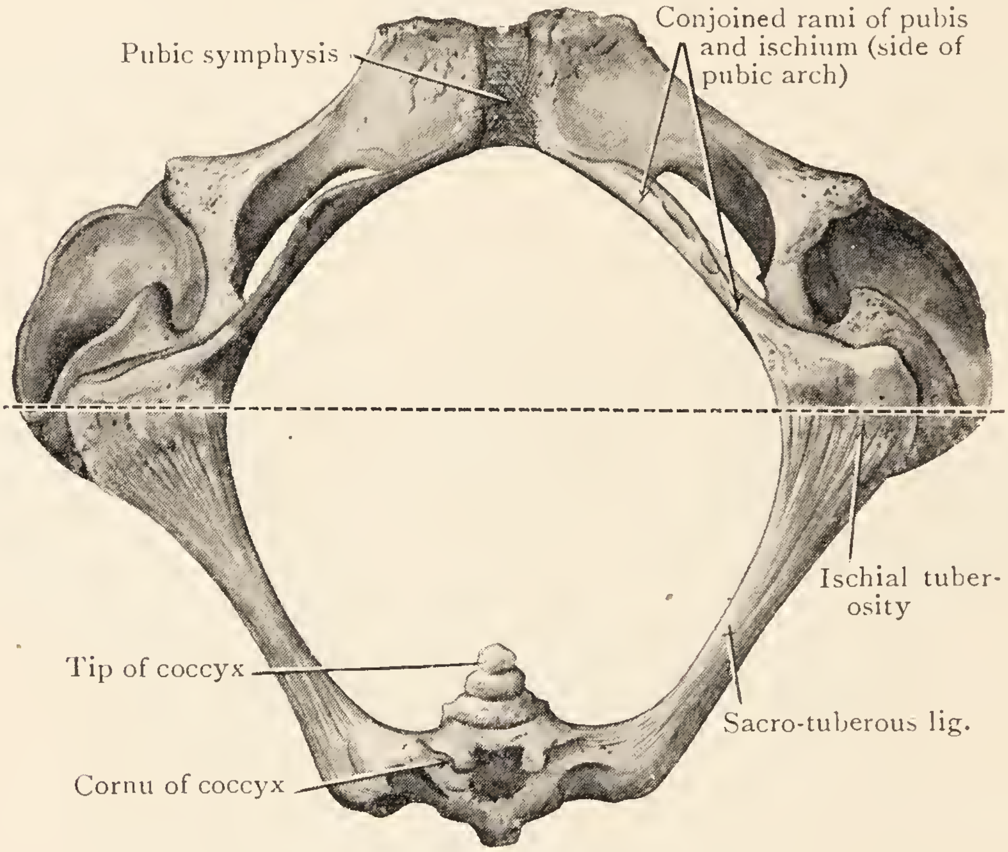


FIG. 78.—Outlet of Female Pelvis.

the lower surface of the penis. The raphe is of special interest because it marks the line along which the floor of the urethra was completed and the two halves of the scrotum fused together during development.

Female External Genital Organs.—The external anatomy of the urogenital triangle in the female demands careful study because it includes the urethral opening and the external genital organs. Under the common term of *pudendum muliebre* or *vulva* the following parts are included:—

1. The mons pubis.
2. A pair of labia majora.
3. A pair of labia minora.
4. The clitoris.
5. The urethral opening.
6. The vaginal orifice.

The **mons pubis** is a cushion-like eminence on the front of the pubes, due to a collection of adipose tissue under the skin. It is covered with hair which ceases abruptly as the mons merges into the anterior abdominal wall.

The **labia majora** correspond to the two halves of the scrotum separated from each other by a median cleft. They are a pair of rounded folds of skin which contain some fat; they begin at the mons pubis, extend downwards and backwards, diminishing in thickness, and meet each other in the median line about an inch in front of the anus. Laterally, they are studded with scattered hairs; medially, the skin is smooth and humid, being lubricated by the semi-solid secretion of numerous sebaceous glands.

The labia majora enclose an elliptical fissure which is termed the *pudendal cleft* and contains the apertures of the urethra and vagina and the remaining external genital organs.

The **labia minora** are a pair of pendulous folds of skin which lie between the labia majora. They represent the prepuce and part of the ventral portion of the penis of the male. To display them fully, pull the labia majora apart; it will then be seen that they are placed one on each side of the vaginal orifice. As they are traced forwards they become more prominent, and at the same time approach each other. When they approach the clitoris, each terminates by splitting into two folds. The smaller and posterior pair of folds are attached to the inferior surface of the clitoris, where they unite to form the *frenulum of the clitoris*. The anterior pair unite over the clitoris like a hood, forming the *prepuce of the clitoris*.

A short distance behind the vaginal orifice, the posterior ends of the labia minora are usually connected together by a transverse ridge of skin called the *frenulum labiorum*; the depression between that ridge and the orifice of the vagina is called the *vestibular fossa* (fossa navicularis). The frenulum labiorum may not be found in the body under examination, for it is usually ruptured during the first labour.

The **clitoris** is the homologue of the penis, and, notwithstanding its small size, it closely resembles the male organ both in appearance and in structure; but it is not traversed by the urethra. It is an elongated projection placed in the anterior part of the pudendal cleft and surmounted by a sensitive, rounded tubercle called the *glans*. The manner in which its prepuce and frenulum are formed has already been described. To obtain a proper view of the clitoris, lay hold of the glans with the forceps and draw it out from the prepuce.

The **vestibule of the vagina** is the interval between the two

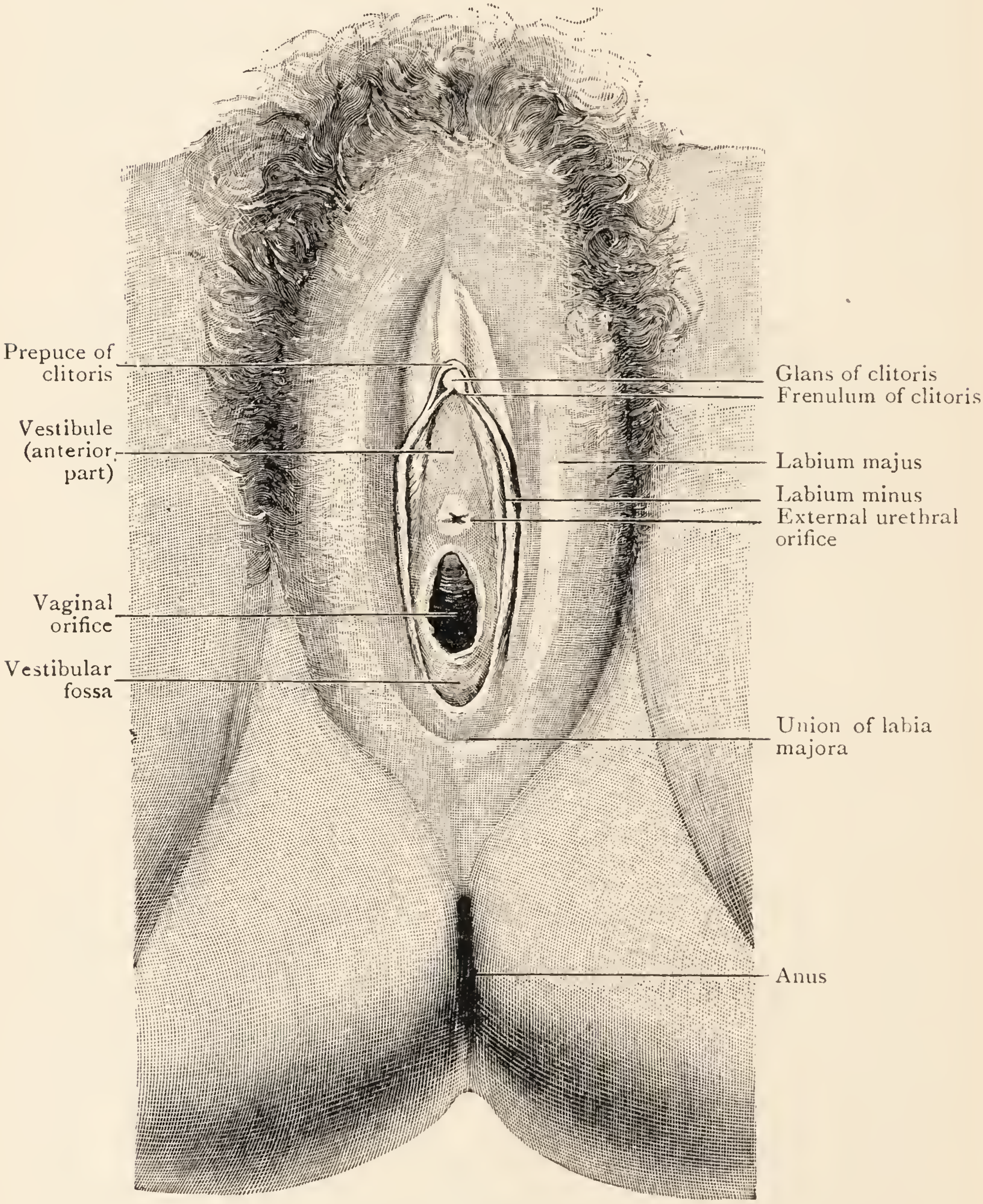


FIG. 79.—Female External Genital Organs.

The frenulum labiorum is seen behind the vestibular fossa. (A. F. Dixon) labia minora. The vagina and the urethra open into it and also the ducts of a pair of glands called the greater vestibular glands.

The **vaginal orifice** is near the posterior end of the vestibule. In the virgin, it is partially closed by the *hymen*—a thin crescentic membrane attached all round the margins of the orifice, and wider behind than in front. The form of the hymen, however, is very variable. After it has been ruptured, its position is marked by small, rounded elevations named *carunculæ hymenales.* Very rarely the hymen completely closes the orifice, and awkward results ensue from the retention of the menstrual fluid.

The duct of the *greater vestibular gland* opens into the groove between the hymen and the posterior part of the labium minus by an aperture just visible to the naked eye.

The **orifice of the urethra** is a small aperture close to the front of the opening of the vagina, about one inch behind the clitoris. Its margins are prominent, pouting, and slightly puckered, so that when the finger-tip is passed over the floor of the anterior part of the vestibule the margins can readily be distinguished by touch.

Principal Contents of Perineum.—Before proceeding farther, the dissectors of **both male and female** perineum will examine certain of the figures and ascertain the position and characters of the structures which, though not yet met with, are referred to incidentally during the early steps of the dissection.

Situated deeply in the **urogenital triangle,** there is a layer of muscle which stretches across the pubic arch (Figs. 85, 87). The main part of the layer is called the *sphincter urethræ*; the posterior part is incompletely separated from the rest to form a pair of small muscles called the *deep transversus perinei.* The upper surface of the layer is covered with the fascia of the pelvis, and its lower surface with a fibrous sheet called the *perineal membrane.* The space (which contains the muscular layer) between the membrane and the fascia is called the *deep perineal pouch.* The urethra passes through these parts in both sexes; in the female, the muscular sheet and the membrane are less obvious than in the male, as they are divided into right and left halves by the passage of the vagina to the pudendal cleft (Figs. 82, 90).

The middle of the posterior border of the perineal membrane is continuous with a mass of fibro-muscular tissue in which various muscles of the perineum meet. It is called the *perineal body*, and lies immediately in front of the anal canal; and it is of greater importance in the female than in the male (Figs. 83, 90).

The three parts of the *root of the penis* (Fig. 86), or the corresponding parts of the clitoris (Fig. 90), lie on the lower surface of the perineal membrane. They are a pair of *crura* and a *bulb* in each sex. The bulb of the penis is in the median plane, while each crus lies along the side of the pubic arch. The crura of the clitoris correspond to the crura of the penis; the bulb of the vestibule corresponds to the bulb of the penis, but, like the other structures, it is divided into right and left halves by the passage of the vagina.

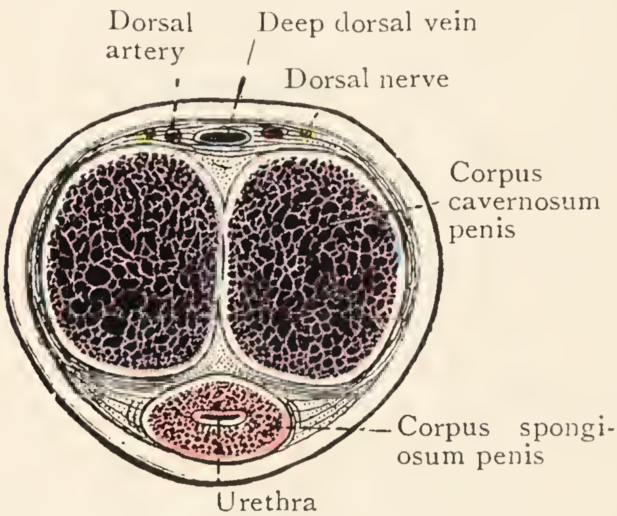


FIG. 80.—Transverse Section through Body of Penis.

Three pairs of small superficial perineal muscles come next:—(1) an *ischio-cavernosus* on each crus (Figs. 83, 89); (2) the *bulbo-spongiosus* muscles on the bulb, united by a median fibrous raphe in the male, divided in the female; and (3) the *superficial transversus perinei* on the posterior border of the perineal membrane. The positions of those muscles should be carefully noted in both sexes, both now and at later stages of the dissection; but their precise attachments, which will be examined after they are cleaned, are not important. Small vessels and nerves are related to them; and they are all concealed by the superficial fascia.

The **anal triangle** (Figs. 83, 89) is divided into a pair of lateral parts, called the *ischio-rectal fossæ*, which are filled with pads of fat, and a median part occupied by (1) the lower part of the anal canal, (2) a muscle called the *sphincter ani externus*, around the canal, and (3) a fibro-fatty mass called the *ano-coccygeal body*, between the canal and the coccyx.

The dissectors of the **female** *perineum will now turn to* *"Passage of Catheter in the Female, etc.", p.* 148.

Penis and Male Urethra.—The penis is partly hidden in the perineum and partly free. Its main constituents are a pair of corpora cavernosa and a single corpus spongiosum—all made of a spongy kind of fibro-elastic tissue (Fig. 80). The *corpora cavernosa* are a pair of thick cylinders united together side by side in the body of the penis, but at its root they separate

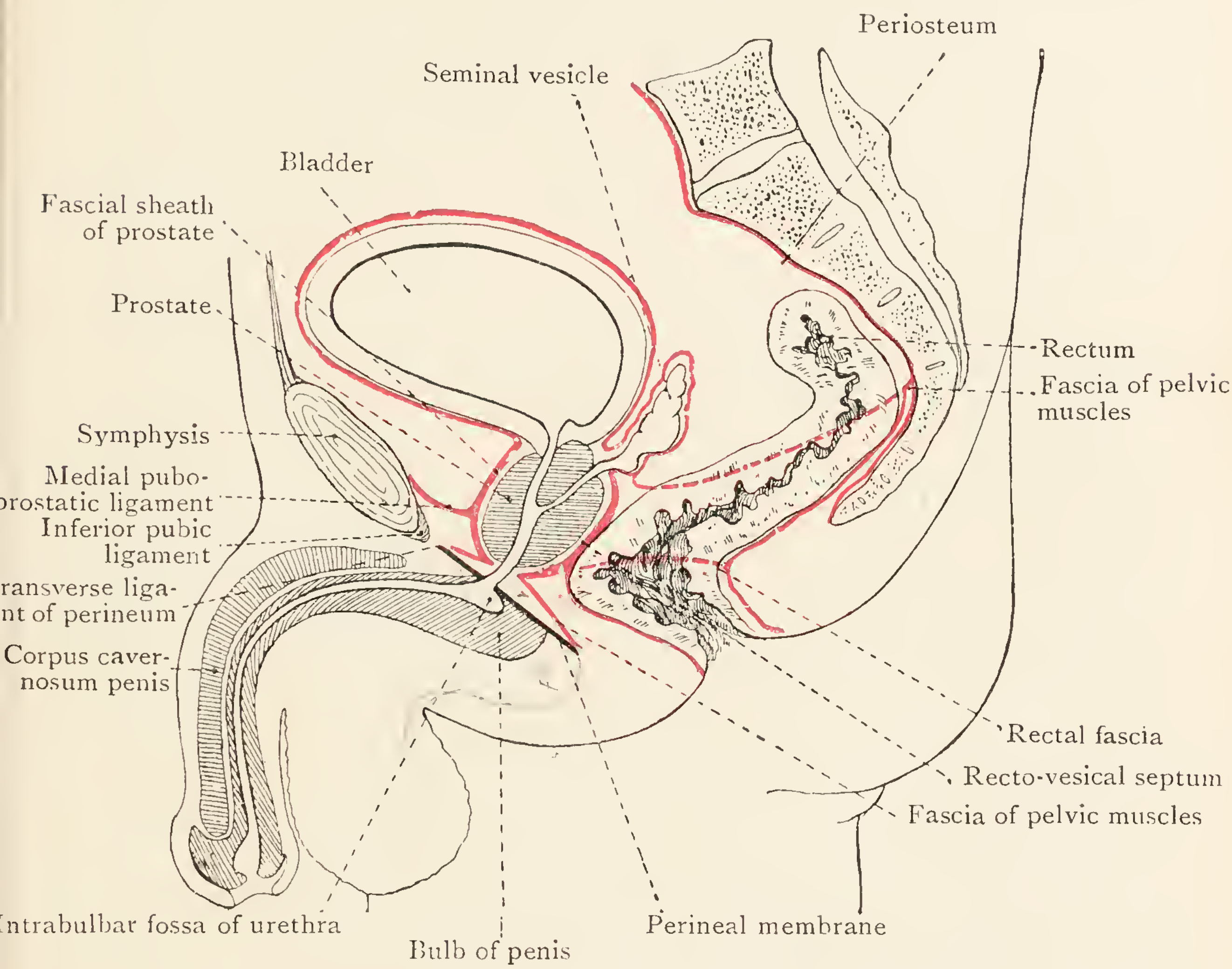


FIG. 81.—Diagram of Urinary Bladder and Urethra, with Fascia of the Pelvic Muscles and Viscera.

and become the crura, each of which tapers to a point posteriorly. The *corpus spongiosum*—much more slender—lies along the lower surface of the united corpora cavernosa, and is traversed lengthwise by the longest of the three divisions of the urethra. Its posterior end is swollen, and is called the *bulb of the penis*. Anteriorly also—at the end of the penis—it enlarges greatly to form the *glans of the penis*, in which the anterior ends of the corpora cavernosa are embedded. The glans may be partly or wholly concealed in the tubular fold of skin called the *prepuce* or foreskin.

The *urethra* is a long tube that extends from the lowest part of the urinary bladder to the end of the glans (Fig. 81), and is divided into three parts. The first part—over an inch long—is called the *prostatic part* because it traverses an organ called the prostate, which lies below the bladder on the fascia that covers the upper surface of the sphincter urethræ. The second part—less than half an inch long—passes through the sphincter to pierce the perineal membrane, and is called the *membranous part*. The third part is called the *spongy part* because it enters the bulb of the penis at once and runs through the corpus spongiosum; it dilates in the bulb to form the *intrabulbar fossa*, and also in the glans to form the *fossa terminalis*.

Before the dissection of the male *perineum is begun, a staff must be passed along the urethra into the bladder.*

Passage of Urethral Staff in the Male.—Stand on the left side of the subject and, holding the penis with the left hand, introduce the staff (smeared with oil or vaseline) into the orifice of the urethra; then, keeping it at right angles to the long axis of the body, pass it along the canal towards the perineum until some resistance is felt—about midway between the root of the scrotum and the anus. Its point is now engaged in the intrabulbar fossa of the urethra immediately below the perineal membrane (Fig. 81).

As the instrument is passed along the spongy part of the urethra its point may be guided with the fingers of the left hand and should be kept in contact with the floor of the canal, because there are depressions in the roof in which it might catch. It has now to be passed onwards through the *membranous* and *prostatic parts*. (1) Rotate the staff until the handle is in the median plane over the lower part of the abdomen; (2) supporting the staff with a finger of the left hand in the perineum, raise it slightly and press the handle of the staff steadily downwards as if to pass it between the thighs. If the manœuvre is successful, the point of the staff will enter the membranous part of the urethra and then pass smoothly through the prostatic part into the bladder. No force is required; and, if any difficulty is experienced in making the point of the staff enter the membranous part, the index finger of the left hand should be introduced into the anal canal and an endeavour made to guide the point of the staff in the proper direction. The passage of the staff may possibly be prevented by stricture of the urethra; but force must not in any case be used, as this invariably results in damage to the parts. In the event of failure, the dissectors should seek an opportunity of passing the staff in a more satisfactory body. The passage of a staff requires a little practice; and each dissector should make a point of repeating the whole operation several times, until proficiency is attained and the feel of the parts transmitted from the point of the instrument has become familiar.

When the staff is in position, note:—that it can be felt through the skin quite easily as far back as the bulb of the penis, but no farther; that it can easily be felt again in the membranous part of the urethra by a finger inserted into the anal canal; but that, at a higher level, as it passes through the prostatic part it is less distinctly felt because it is covered by the posterior part of the prostate.

Now, stitch the most dependent part of the scrotum to the prepuce; drag both penis and scrotum forwards on the staff and tie them in position. Next, tie the handle of the staff to the cord which passes between the knees. Lastly, introduce a little tow, steeped in preservative fluid, into the anal canal and stitch up the orifice of the anus.

The dissectors of the male *pelvis will now proceed to reflect the skin—**See next page.*

Passage of Catheter in the Female and Examination of Os Uteri Externum.—Before the dissection of the female perineum is begun, examine Fig. 82 and note the position of the urethra and the vagina; then, practise passing the female catheter, and insert a speculum into the vagina in order to examine the external os uteri.

Obtain a female catheter, and then place the forefinger of the left hand in the orifice of the vagina with its palmar surface directed upwards towards the pubes. If the instrument is now directed along this finger, and the point raised slightly when it reaches the entrance to the vagina, a little manipulation will cause it to enter the urethra, and it can then be pushed onwards into the bladder.

When the speculum is introduced into the vagina, the points to be noted in connection with the os uteri are:—(1) the small size of the opening; (2) the rounded and thick lips which bound the aperture in front and behind—the anterior lip being the thicker and shorter. It is a transverse cleft; and in women who have not borne children it is small and its lips are smooth and rounded, but in parous women it is usually larger and its lips are frequently cleft and scarred.

Now, stitch the labia minora together; then, moisten a little tow with preservative fluid, place it in the anal canal and stitch up the anal orifice.

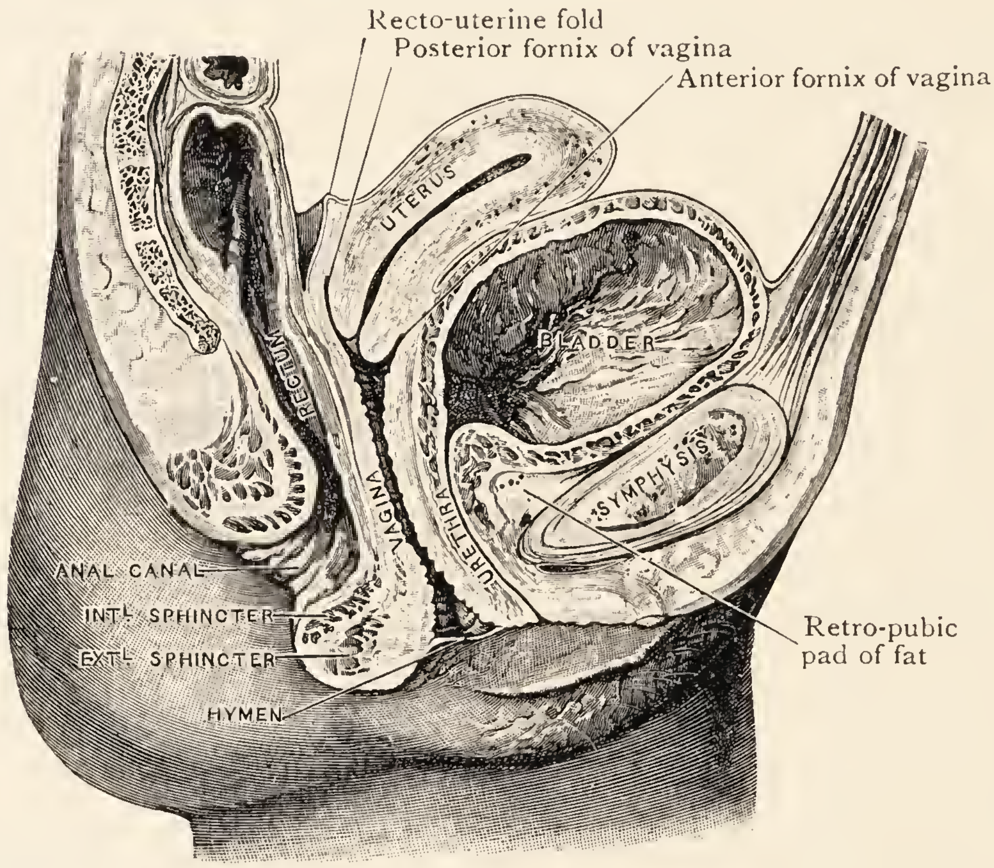


FIG. 82.—Median Section through Female Pelvis.

Dissection. — Reflexion of Skin. — (1) Make a transverse incision from one ischial tuberosity to the other, immediately in front of the anus.

In the male (2) begin a median cut well forwards on the scrotum and carry it back a little beyond the point of the coccyx, encircling the anus on the way.

In the female (2) run incisions round the anus and the pudendal cleft separately; join them by a median cut, and make another median cut from the anus to the coccyx.

Reflect the four flaps thus marked out. As the posterior flaps are raised a number of involuntary muscle-bundles will be found radiating from the anus—the *corrugator cutis ani.*

Superficial Fascia.—The superficial fascia must be examined carefully. It shows great differences in character and texture in different parts of the perineal area.

At the sides of the anus it is remarkable for the large quantity of fat it holds in its meshes. This fat is soft and lobulated, and passes upwards into the ischio-rectal fossa in the form of a pliable and elastic pad. Over the urogenital triangle a change in the character of the superficial fascia becomes manifest, and it can be shown to be divided into two layers—a superficial and a deep.

The *superficial layer* is fatty, and, at the margins of the triangle, it is continuous with the superficial fascia of adjoining parts of the body.

The *deep layer* is of a different nature. It is thin and membranous—firmer and more obvious in the male than in the female—and has definite connexions at the base and sides of the triangle. Thus, posteriorly, it curves upwards behind the superficial transverse muscle to fuse with the posterior border of the perineal membrane. On each side, it is attached to the margin of the pubic arch. A space is thus enclosed called the *superficial perineal pouch.* It is bounded inferiorly by the membranous layer of fascia, superiorly by the perineal membrane, laterally by the side of the pubic arch between the attachments of the two membranes; and it is closed posteriorly by their fusion. Anteriorly, it is open and is continuous with the interval between the superficial fascia and the aponeuroses of the external oblique muscles of the anterior abdominal wall—an interval filled with areolar tissue.

In the female, the fat of the *superficial layer* is abundant in the labium majus; but the fat disappears when it is traced into the labium minus. The *membranous layer* passes deep to the fat of the mons pubis to become continuous with the corresponding membranous layer of the anterior wall of the abdomen. The *superficial perineal pouch* is divided into halves by the pudendal cleft and the lower end of the vagina. Each half contains the crus of the clitoris, the bulb of the vestibule, the greater vestibular gland, and the superficial perineal muscles, nerves and vessels.

Dissection.—Expose the membranous layer of the superficial fascia by removing the fatty layer in the labium majus, and make a small incision into the superficial perineal pouch. Insert the tip of the little finger, explore in various directions, and note that the finger can pass easily only in the forward direction over the pubis to the anterior abdominal wall.

The dissectors of the female *abdomen will now pass to the study of the Anal Triangle, p.* 152.

In the male, the change in the character of the superficial fascia is more striking than in the female. Not only is it divided into two layers, but also the farther forward it is

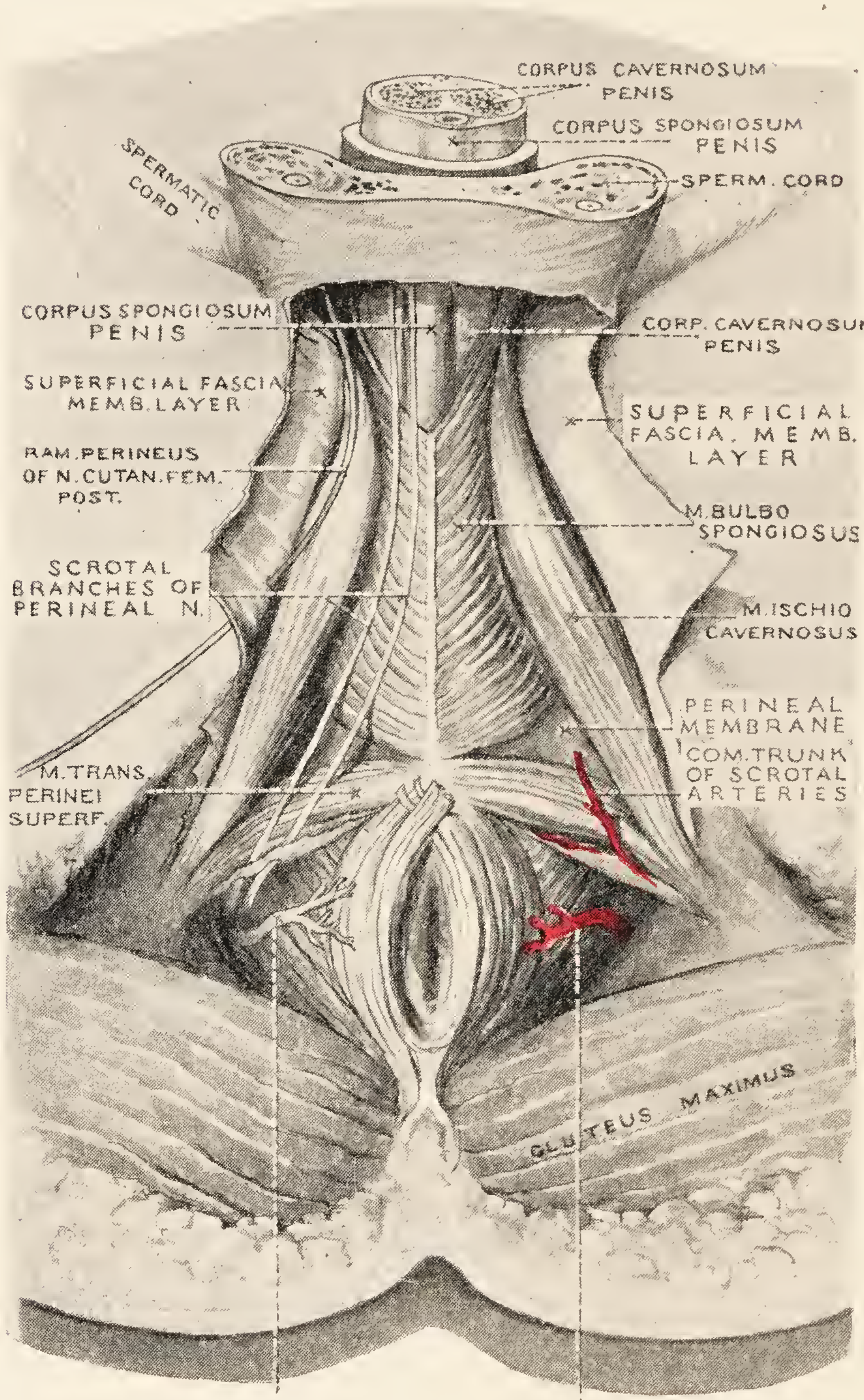


FIG. 83.—Dissection of Perineum. The Scrotum and the Penis have been cut across transversely and removed.

traced the scarcer becomes the fat in its meshes. In the scrotum the fat entirely disappears and gives place to a thin layer of involuntary muscular fibres; these constitute the *dartos muscle* and are recognised by their ruddy colour; the rugosity of the scrotal skin is caused by their contraction.

Towards the front of the perineum, both layers of the superficial fascia are continuous with the dartos muscle; and the membranous layer is continuous with the deep layer of the superficial fascia of the abdomen. The superficial perineal pouch is partially divided into right and left halves by a median septum which dips from the fascia to a fibrous raphe between the bulbo-spongiosus muscles. The septum is very perfect posteriorly, but it becomes incomplete towards the scrotum. Within the pouch certain important parts are placed—viz., the superficial perineal muscles, vessels and nerves, and the bulb and crura of the penis.

It follows, from what has been stated, that if the spongy portion of the urethra is injured in the perineum and urine escapes from it to one or other side of the median plane, it will first distend the corresponding half of the posterior part of the superficial pouch; next, having reached the limit of the septum, it will pass into the opposite half and distend it. Then, because it cannot escape either backwards or sidewards on account of the attachments of the fascia, it will make its way forwards and upwards into the areolar tissue under cover of the superficial fascia of the abdominal wall; and it may ascend as far as the thorax unless exit is made for it by free incisions into the pouch. The extravasated urine which has reached the wall of the abdomen cannot descend into the thighs because of the attachment of the deep layer of the superficial fascia of the abdomen to the deep fascia of the thigh near the groove of the groin.

Dissection.—The students can demonstrate these facts in two ways, viz.:—(1) by inflating the pouch with air, and (2) by dissection. Make a longitudinal incision, large enough to admit the nozzle of the bellows (or, better still, an injection pipe fitted to a bicycle-pump), into the superficial fascia towards the posterior part of the pouch and a little to one side of the median line. Carry the cut through the fascia until the fibres of the superficial muscles are exposed. Introduce the nozzle of the bellows (or injection pipe) through the cut, hold the margins of the opening tightly round it, and force air into the pouch.

The air will first fill one side of the pouch; it will then pass forwards to the scrotum, where the septum is incomplete, and will force its way across the median plane to the opposite side. Afterwards, as more air is pumped in, it will pass forwards to the abdomen. The pouch is thus made prominent and a very striking view obtained of the course which would be taken by urine that escapes from a rupture in the urethra below the perineal membrane. Note the attachments of the membranous layer of the superficial fascia as thus demonstrated by the limits of the distended pouch—posteriorly to the posterior border of the perineal membrane, laterally to the sides of the pubic arch.

These attachments are so important that the students should test them by dissection also.

Dissection.—Make a pair of incisions through the superficial fascia from the median line at the root of the scrotum to the ischial tuberosities. A central Λ-shaped flap and a pair of collateral flaps of fascia are thus marked out. Raise each of these in turn to demonstrate the attachments of the fascia and the septum of the pouch. As this dissection is made, great care is required. In the areolar tissue immediately subjacent to the superficial fascia there are the *scrotal vessels* and *nerves*, which are certain to be injured, or perhaps even reflected with the fascia, unless the greatest caution is exercised.

Anal Triangle

The dissection of the anal triangle will disclose the following parts :—

1. Sphincter ani externus muscle.
2. Anal canal.
3. Ano-coccygeal body.
4. Ischio-rectal fossa.
5. Lower border of the gluteus maximus muscle and the sacrotuberous ligament.
6. Levator ani muscle, covered with fascia.
7. Obturator internus muscle and obturator fascia.
8. Pudendal canal.
9. Inferior hæmorrhoidal nerve.
10. Inferior rectal artery.
11. Scrotal or labial branches of perineal nerve.
12. Scrotal or labial and transverse perineal branches of internal pudendal artery.
13. Perineal branch of fourth sacral nerve.

Median Part of Anal Triangle.—As mentioned before, the **anal canal** lies in the median part of the triangle. It is an inch and a half long, and is continuous with the part of the large intestine called the rectum ; it extends downwards and backwards from the rectum to the anal orifice. Its upper part lies in the pelvis, and is related on each side to the lower portion of a wide, thin curved sheet of muscle called the *levator ani.* This muscular sheet slopes downwards and medially from the fascia that covers the obturator internus on the side wall of the pelvic cavity; it forms nearly the whole of the medial wall of the ischio-rectal fossa, and is covered with fascia. The circular, non-striped muscular fibres of the upper part of the anal canal form a thickened ring called the *sphincter ani internus.* The lower part of the canal is in the perineum, and is surrounded by bundles of striped muscle-fibres called the *sphincter ani externus.*

The **ano-coccygeal body** is an ill-defined mass of muscular and fibrous tissue permeated with fat. It lies between the anus and the tip of the coccyx, and is seen best in sections through the pelvis; and it requires notice on account of the support which it gives to the anal canal and the lower part of the rectum. The muscular tissue in it belongs to the levator ani and the external sphincter.

After the removal of the skin, the first step in the dissection is the exposure of the sphincter ani externus.

> ***Dissection.***—Make an incision through the fascia which covers the external sphincter—from the tip of the coccyx to the anus, forwards round the sides of the stitches which were used to close the anus, and then onwards to the perineal body in the median plane. Reflect the fascia to each side and, as the borders of the external sphincter are defined, find and clean the branches of the *inferior rectal artery* and secure the branches of the *inferior hæmorrhoidal nerve* and the *perineal branch of the fourth sacral nerve* which supply the muscle.

The **sphincter ani externus** is a thick ring of muscular fibres which surround the lower part of the anal canal, and are arranged in three layers—subcutaneous, superficial and deep. The *subcutaneous fibres* are without bony attachment; they surround the anal orifice, and some of them decussate in front of it (Figs. 83, 89). The *superficial fibres* spring from the ano-coccygeal body and the last piece of the coccyx, and sweep forwards round the sides of the anus to be inserted into the perineal body, where some of them are continuous with other superficial perineal muscles also inserted there. The *deep fibres* encircle the lower half or more of the anal canal and form a true sphincter muscle, which, like the subcutaneous layer, has no direct bony attachment. The deep layer of the external sphincter is intimately associated with the pubo-rectalis portion of the levator ani, which strongly reinforces its action on the anal canal (p. 428).

The external sphincter of the anus draws its nerve supply from two sources, viz., the *perineal branch of the fourth sacral nerve* and the *inferior hæmorrhoidal nerve*.

The students should note that the disposition of the layers of the sphincter ani externus and their relation to the anal canal are of some importance in determining the track of an anal fistula (p. 155).

Ischio-Rectal Fossa.—The next step in the dissection is the display of the ischio-rectal fossa; but, before beginning, the dissectors should have a general idea of its position, boundaries and contents.

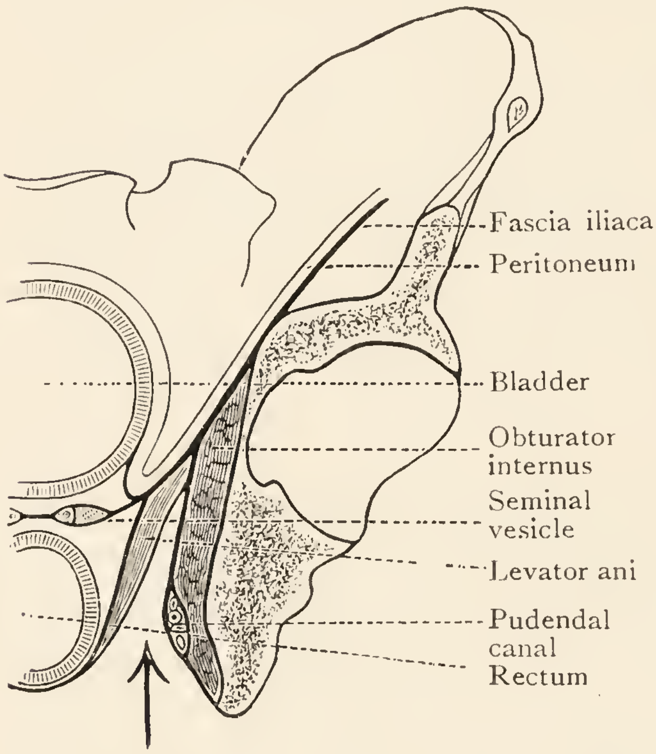


FIG. 84.—Diagram. The arrow is directed upwards into the ischio-rectal fossa. The obturator fascia is seen on the medial surface of the obturator internus. Observe also the fascia clothing the levator ani.

The space known as the *ischio-rectal fossa* is the wedge-shaped interval that separates the ischium from the structures in the median area of the anal triangle, and it is occupied mainly by fat. The *inferior* boundary of the fossa, or base of the wedge, is the skin of the perineum. The edge or *superior* boundary is at the origin of the levator ani from the obturator fascia (Fig. 84). The *anterior* boundary is formed by the superficial and deep transversus perinei muscles (covered with fascia) and the posterior border of the perineal membrane between them; and the *posterior* boundary is made up of the sacro-tuberous ligament and the lower border of the gluteus maximus, which overlies the ligament. The *medial* boundary or wall is composed of the levator ani and the external sphincter, with the fascia that covers them. This wall separates the fossa from the anal canal and the lower part of the rectum, and slopes upwards and laterally to meet the lateral boundary at the upper limit of the fossa, where the fascia of the levator blends with the obturator fascia. The *lateral* wall is nearly vertical. It is composed of the obturator internus muscle where it lies on the pelvic surface of the ischium, and by the obturator fascia, which clothes the medial surface of the muscle. It will be seen, therefore, that, although the fossa is named "ischio-rectal," neither the ischium nor the rectum forms an immediate boundary.

The fossa is widest and deepest posteriorly, where it reaches two and a half inches above the level of the lower end of the ischium; and it is narrowest and shallowest anteriorly. The medial wall is the weakest, for the muscles and fasciæ that compose it are thin. If an abscess forms in the fossa, pus is apt to force its way through the medial wall into the anal canal; and, if the abscess bursts also externally, an "anal fistula" results. An *ischio-rectal abscess* should be opened therefore as soon as possible by incisions through the skin of the base of the fossa.

In the lateral wall, the obturator fascia splits to enclose a tunnel called the *pudendal canal* (Fig. 84). The canal begins near the lower part of the lesser sciatic foramen, and (in the erect posture) runs downwards and forwards to the posterior border of the perineal membrane, where it opens into the deep perineal pouch. The internal pudendal vessels course through the canal, with the dorsal nerve of the penis (or clitoris) above them and the perineal nerve below them. These structures raise up the medial wall of the canal as a ridge that can be felt by the finger-tip about an inch and a half above the lower end of the ischium, after the fossa has been dissected.

Contents of Ischio-Rectal Fossa.—These are :—

1. A soft, elastic *pad of fat*, which fills the cavity.
2. The *inferior hæmorrhoidal nerve*, which runs latero-medially across the fossa through the fat.
3. The *inferior rectal vessels*, which accompany the hæmorrhoidal nerve.
4. In the anterior part of the fossa, portions of the *scrotal nerves and vessels* (*labial* in the female), and the *transverse perineal vessels*.
5. The *perineal branch of the fourth sacral nerve*, running to the external sphincter from the posterior angle of the fossa.

The dissectors will now define the boundaries of the fossa, and clean the vessels and nerves in it.

Dissection.—Begin by exposing the lower margin of the *gluteus maximus* muscle. Take a point a short distance to the lateral side of the ischial tuberosity and another in the median plane about an inch above the tip of the coccyx, and cut boldly down through the superficial fascia, in a line between those points, until the fleshy fibres become visible. Look for small *gluteal branches of the posterior cutaneous nerve of the thigh*, which wind round the lower border of the gluteus maximus lateral to the ischial tuberosity. Then, clean the lower border of the gluteus maximus, and proceed to dissect the ischio-rectal fossa.

First, separate the fat from the gluteus maximus with the handle of the knife ; find the *sacro-tuberous ligament* by pulling back the part of the gluteus maximus that conceals it, and clean the lower edge of the ligament. Detach the fat from the lateral wall of the fossa, partly with the blade of the scalpel and partly with the handle, and push it forwards and medially, taking care not to injure any vessels or nerves. Now, dissect cautiously in a transverse direction, from the angle between the gluteus maximus and the ischial tuberosity towards the anus, and secure the *inferior hæmorrhoidal nerve* and *inferior rectal vessels*. Follow them to their termination in the medial wall. Next, dissect carefully in the angle between the lateral wall of the fossa and the perineal membrane, and find the *scrotal vessels and nerves* (*labial branches* in the female). Trace them into the superficial perineal pouch. Find also the *transverse perineal artery*, which runs medially from one of these arteries.

Find the *perineal branch of the fourth sacral nerve* in the posterior corner of the fossa, and trace it to the external sphincter.

Lastly, remove the remains of the fat from the fossa.

The dissectors will now study the contents of the fossa.

The **ischio-rectal pad of fat** acts as an elastic cushion which allows the anal canal to expand as the fæces are expelled through it, and assists in closing the canal after the fæces have passed.

Portions only of the **internal pudendal artery** and **pudendal nerve** appear in the present dissection. If the students have already dissected the Lower Limb, they should recall to mind the fact that they displayed these structures during the dissection of the gluteal region when the parts exposed by the reflexion of the gluteus maximus were cleaned. There, they were seen to emerge from the pelvis through the greater sciatic foramen, to pass over the spine of the ischium and the sacrospinous ligament and to disappear into the perineum through the lesser sciatic foramen. Now, they are met with again in this region as they pass forwards in the pudendal canal into the urogenital triangle, where they will presently be dissected ; their origin, and their course within the pelvis, will be studied at a later stage.

For the present, the dissectors must be satisfied with palpating these structures as they lie in the pudendal canal. To expose them they would have to divide the obturator fascia, and that must be kept intact until the interior of the pelvis is studied. They should, however, note that:—(1) the pudendal nerve, as soon as it enters the canal, gives off its inferior hæmorrhoidal branch, and then divides into the perineal nerve and the dorsal nerve of the penis (or clitoris), which lie respectively below and above the artery and its venæ comitantes; (2) the inferior hæmorrhoidal nerve and inferior rectal vessels pierce the medial wall of the canal near its posterior end; and (3) the scrotal (or labial) nerves and vessels, which spring from the perineal nerve and pudendal vessels, pierce it near the anterior end.

The **inferior hæmorrhoidal nerve** may proceed directly from the second and third sacral nerves, but more frequently it is a branch of the pudendal nerve and arises as that nerve enters the pudendal canal. It perforates the medial wall of the canal, passes medially through the ischio-rectal fat, communicates with the scrotal (or labial) nerves and the perineal branch of the posterior cutaneous nerve, and divides to supply the levator ani, the external sphincter and the skin around the anus.

The **inferior rectal** (hæmorrhoidal) **arteries,** usually two or three in number, are branches of the internal pudendal. They accompany the inferior hæmorrhoidal nerve and its branches, and also send a few twigs round the lower border of the gluteus maximus to supply the skin of the buttock.

The **perineal branch of fourth sacral nerve** is a slender nerve which enters the ischio-rectal fossa at the side of the coccyx. It supplies the sphincter ani externus and the skin behind the anus.

The further dissection of the perineum is described separately for male and female. The dissectors of the **female** *perineum will pass on to p.* 169.

Urogenital Triangle in the Male

The superficial fascia of the urogenital triangle has already been studied (p. 148) and partly reflected. The following structures now require to be dissected :—

1. Scrotal vessels and nerves.
2. Perineal branch of posterior cutaneous nerve of thigh.
3. Root of penis—bulb and crura.
4. Superficial perineal muscles.
   - *a.* Superficial transversus perinei
   - *b.* Bulbo-spongiosus.
   - *c.* Ischio-cavernosus.
5. Perineal membrane.
6. Internal pudendal vessels and their branches.
7. Dorsal nerve of penis, and branches of perineal nerve.
8. Deep perineal muscles.
   - *a.* Deep transversus perinei.
   - *b.* Sphincter urethræ.
9. Bulbo-urethral glands.
10. Membranous part of urethra.
11. The layer of pelvic fascia opposite the pubic arch.

Dissection.—Clear away the remains of the superficial fascia from the urogenital triangle. Find the *scrotal arteries and nerves* in the anterior part of the ischio-rectal fossa; trace them to the scrotum, and the *transverse perineal artery* medially along the superficial transverse muscle. Look for the *perineal branch of the posterior cutaneous nerve of the thigh* about one inch in front of the ischial tuberosity. Trace its branches to the scrotum, and its trunk into the fascia of the thigh. As the nerves are followed, three muscles will be more or less displayed:—the *ischio-cavernosus* along the margin of the pubic arch; the *bulbo-spongiosus* near the median plane; and the *superficial transversus perinei* crossing between their posterior ends.

Superficial Perineal Nerves and Vessels.—These small structures should now be studied (Fig. 83).

Two *scrotal nerves*—a lateral and a medial—arise from the perineal nerve in the anterior part of the pudendal canal, and pierce the medial wall of the canal to enter the anterior part of the ischio-rectal fossa. They then enter the superficial perineal pouch by piercing the membranous layer of the superficial fascia, pass either above or below the superficial transversus perinei muscle, and run forwards, supplying the skin of the anterior part of the perineum; and they end in slender branches which supply the wall of the scrotum.

Two *scrotal arteries* arise in the pudendal canal from the internal pudendal artery, and accompany the nerves. The *transverse perineal artery* arises from one of them and runs medially along the superficial transverse muscle.

The *perineal branch of the posterior cutaneous nerve of the thigh* pierces the deep fascia of the thigh a short distance in front of the ischial tuberosity, and about an inch and a half to the lateral side of the margin of the pubic arch; it then inclines medially and passes forwards to supply the lateral and anterior parts of the wall of the scrotum.

Dissection.—Divide the scrotal nerves and arteries near their terminations and turn them aside ; then, with the handle of the scalpel, enlarge the interval between the three superficial perineal muscles. The fibrous sheet which forms the deep boundary of the triangular area thus displayed is the perineal membrane (Fig. 83).

Superficial and Deep Perineal Pouches.—At this stage of the dissection the students should consider the position of the perineal membrane and the structures which lie superficial and deep to it.

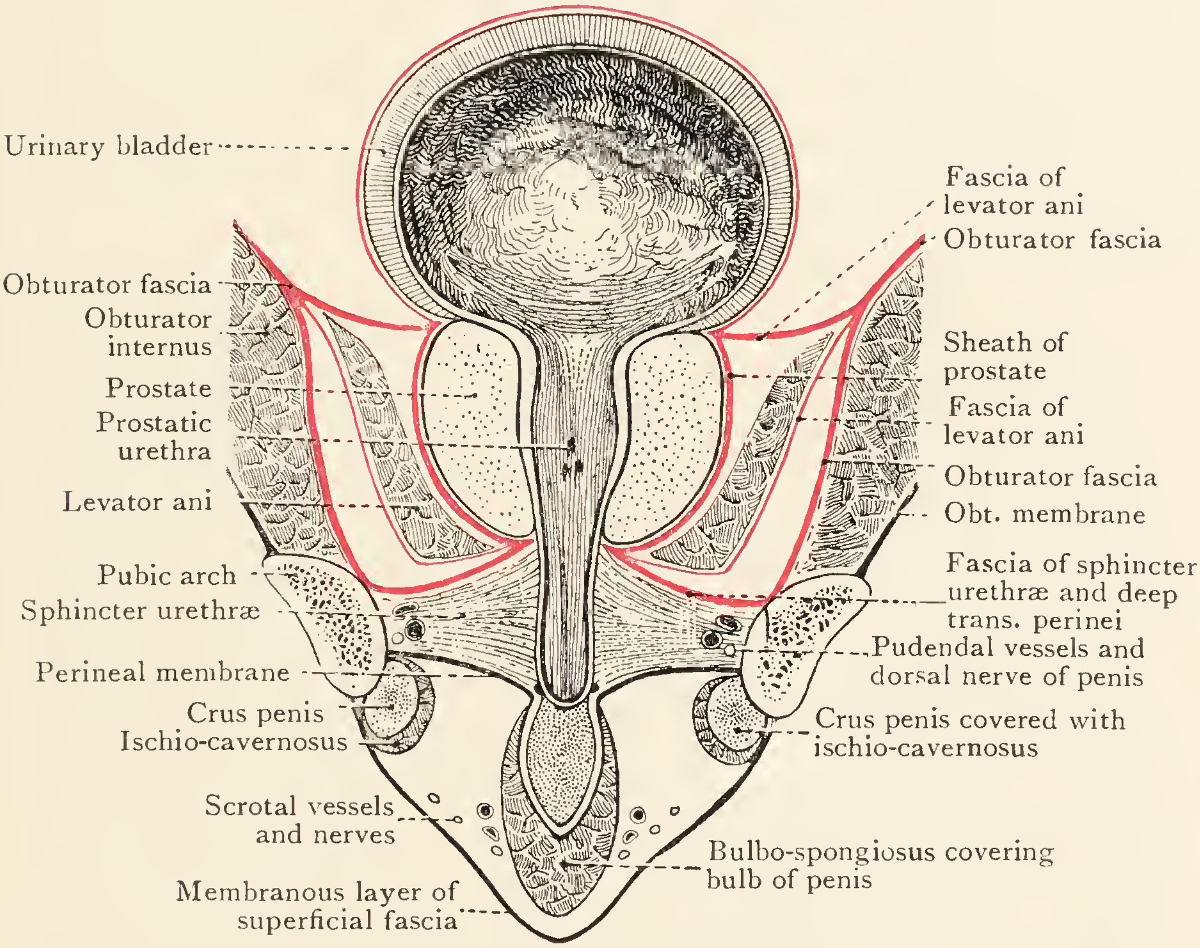


FIG. 85.—Schematic Coronal Section to show the two Perineal Pouches.

The *perineal membrane* is a strong fibrous partition which stretches across the pubic arch and separates the superficial from the deep perineal pouch. The **superficial perineal pouch** is enclosed between the perineal membrane and the membranous layer of the superficial fascia ; the most important structures which it contains are the constituents of the *root of the penis*, namely, the bulb and a pair of crura. The *bulb* of the penis lies in the median part of the pouch and forms a rounded eminence which is covered by the bulbo-spongiosus muscles. Each *crus* lies in the lateral part of the pouch along the side of the pubic arch, and forms an elongated elevation which is covered by the ischio-cavernosus muscle.

Deep to the perineal membrane there is another space, known as the **deep perineal pouch,** which is limited internally by a layer of the fascia of the pelvic muscles.

The most important structure in the deep perineal pouch is the membranous part of the urethra, which enters the pouch from the pelvis by piercing that layer of pelvic fascia and leaves it by piercing the perineal membrane. The pouch contains also :—(1) the sphincter urethræ muscle ; (2) a pair of deep transversus perinei muscles ; (3) a pair of bulbo-urethral glands ; (4) the internal pudendal artery of each side with its venæ comitantes and (5) its branch to the bulb of the penis ; (6) the dorsal nerve of the penis ; and (7) terminal branches of the perineal nerve.

Dissection.—Clean the superficial perineal muscles ; define the constituent parts of the root of the penis and follow them forwards until they unite to form the body of the penis.

Then, separate the superficial transverse muscle from the perineal body, turn it aside, and look for the terminal twigs of the perineal nerve, which pass deep to the muscle. Now, with the knife, separate the two bulbo-spongiosus muscles from each other and display their attachments by turning them laterally ; trace their anterior fibres forwards on to the dorsum of the penis.

Superficial Perineal Muscles.—Under this heading are included the bulbo-spongiosus, the ischio-cavernosus, and the superficial transversus perinei muscles. They lie between the superficial fascia and the perineal membrane ; but each muscle is invested by its own delicate layer of deep fascia. They are supplied by twigs from the perineal nerve.

The **superficial transversus perinei** muscle is a narrow slip of muscular fibres which arises from the ramus of the ischium close to the tuberosity, and passes medially to unite with its fellow of the opposite side in the perineal body.

The *perineal body* is a fibro-muscular structure situated in the median plane at the *central point of the perineum*, between the anal canal and the bulb of the penis. Towards it a number of the perineal muscles converge to obtain attachment, and the interlacement of their tendinous fibres contributes to its formation. It gives attachment, *on each side*, to a superficial transversus perinei ; *posteriorly*, to the sphincter ani externus ; *anteriorly*, to the posterior fibres of the bulbo-spongiosus ; and, *superiorly*, some of the anterior fibres of the levator ani descend to reach it.

The **bulbo-spongiosus** muscles are spread over the bulb and the posterior part of the corpus spongiosum of the penis, and are united to each other by a median fibrous raphe. Their fibres take origin from the perineal body and from the raphe. The insertion differs according to the point at which the muscle is examined. The *posterior fibres* are attached to the lower surface of the perineal membrane; the *middle fibres*, constituting the greater part of the muscle, sweep around the corpus spongiosum so as to invest it completely, and are inserted into an aponeurosis on its upper surface; lastly, the *anterior fibres* form two long, narrow muscular bands which diverge from each other like the limbs of the letter V. They pass forwards over the sides of the corpora cavernosa of the penis, and are inserted into an aponeurosis on the dorsum of the penis. Thus, the *posterior fibres* partially embrace the bulb; the *middle fibres* embrace the corpus spongiosum; and the *anterior fibres* embrace the body of the penis. The arrangement of the fibres shows clearly that when the muscles of the two sides act together they must compress the bulb, the corpus spongiosum and the corpora cavernosa. The bulbo-spongiosus muscles also support the urethra during micturition, and, by their contraction, eject the last drops of urine or semen from the passage.

The **ischio-cavernosus** muscle lies on the crus penis. It arises by fleshy fibres from the medial side of the ramus of the ischium close to the tuberosity, and is inserted, by an aponeurotic expansion, into the lower and lateral surface of the anterior portion of the crus.

Crura and Bulb of Penis.—The *crura penis* are the posterior parts of the corpora cavernosa penis, which together form the dorsal part of the body of the penis. Each crus is attached to the medial surface of the side of the pubic arch and to the adjacent part of the lower surface of the perineal membrane. Its superficial surface is covered by the ischio-cavernosus muscle, and gives insertion to it. The deep artery of the penis enters the anterior part of its deep surface, and the corresponding vein issues from it at the same point to join one of the venæ comitantes of the internal pudendal artery.

The *bulb of the penis* is the posterior expanded part of the corpus spongiosum penis. The corpus spongiosum lies in a groove on the lower surface of the united corpora cavernosa. At the free end of the penis the corpus spongiosum enlarges into a cap-like expansion, called the *glans penis*, which covers the anterior ends of the corpora cavernosa. Posteriorly, it separates from the corpora cavernosa and again enlarges to form the bulb (Figs. 85, 86).

The bulb is attached to the inferior surface of the perineal membrane by fibrous tissue and by the bulbo-spongiosus muscles. Immediately in front of its posterior end, certain structures enter it after they have pierced the perineal membrane, namely, the urethra, the ducts of the bulbo-urethral glands, and the arteries of the bulb—one from each internal pudendal artery. The posterior end of the bulb is frequently divided by a median notch which indicates its bilateral origin.

Structure.—The corpora, the crura, the bulb and the glans are all made of a fibro-elastic sponge-work whose spaces are lined with endothelium. The sponge-work is called *erectile tissue*, for the spaces are filled with blood and their distension with blood causes erection of the penis. The corresponding parts in the female also are made of erectile tissue.

The penis as a whole, including its structure, will be studied with the dissection of the anterior abdominal wall (p. 225).

Perineal Nerve.—This is one of the terminal branches of the pudendal nerve. It arises in the posterior part of the pudendal canal, and runs forwards, in the canal, below the internal pudendal artery. Near the anterior end of the canal it gives off the two scrotal nerves (p. 158), and soon afterwards divides into terminal branches. Some of them enter the superficial perineal pouch to supply the superficial perineal muscles and the bulb of the penis, while the others enter the deep pouch to supply the deep transversus perinei and the sphincter urethræ.

The perineal membrane must now be exposed.

Dissection.—Remove the superficial perineal muscles. Detach one crus penis, with the ischio-cavernosus, from the bone and the perineal membrane ; begin at its posterior end, and pass carefully forwards until the deep artery of the penis is found entering the crus. Clean the artery, and secure the dorsal artery and dorsal nerve of the penis, which are close to it. Then, turn to the bulb of the penis. Detach its posterior end from the perineal body and turn it carefully forwards ; identify the urethra, and secure the arteries of the bulb as they enter it. Do not injure either the arteries or the urethra, but clean the superficial surface of the perineal membrane as far as possible.

Perineal Membrane.—This structure is now seen to be a strong fibrous sheet which stretches across the pubic arch. It may be regarded as lying in the same morphological plane as the bony and ligamentous wall of the pelvis—filling up the pubic archway much in the same manner as the obturator membrane fills up the obturator foramen.

On each side, the perineal membrane is attached to the medial surface of the conjoined rami of the pubis and ischium. Its posterior border has already been seen to blend with the membranous superficial fascia along the posterior border of the superficial transversus perinei muscles ; and it blends also with the fascia that covers the posterior surface of the deep transversus—thus closing the deep perineal pouch posteriorly. In addition to those attachments, however, a careful dissection, in a good subject, will show that the middle part of the border projects backwards in the form of a short process which joins the perineal body. Near the pubic symphysis, the anterior margin of the membrane is fused with the fascia on the anterior border of the sphincter urethræ—thus closing in the deep pouch anteriorly. The fused anterior border is slightly thickened to form a band called the *transverse ligament of the perineum*. This ligament is separated from the inferior pubic ligament by an oval gap through

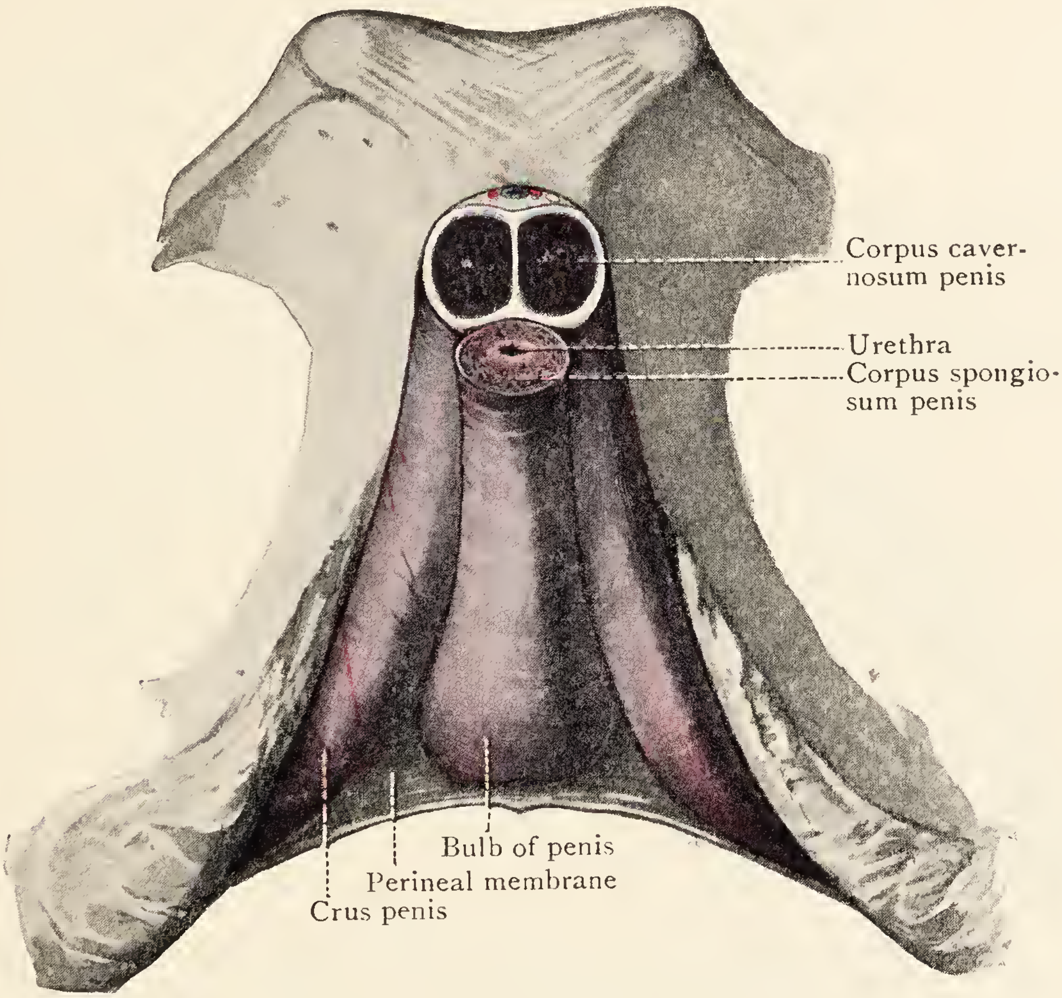


FIG. 86.—Root of Penis, and the Corpora seen in Section.

which the deep dorsal vein of the penis ascends into the pelvis (Figs. 81, 87).

In the erect posture of the body, the superficial surface of the perineal membrane looks directly downwards, and its deep surface looks upwards towards the cavity of the pelvis. Its lower surface is in close contact with the bulb, the two crura, the muscles associated with them, and the superficial transversus perinei muscles. The structures which lie above the membrane will be studied after it has been reflected.

The perineal membrane is not an unbroken, continuous layer. It is pierced :—(1) by the urethra ; (2) by the internal pudendal arteries or their terminal branches ; (3) by the dorsal nerves of the penis ; (4) by the arteries of the bulb.

The *aperture for the urethra* is situated in the median plane, one inch behind the pubic symphysis. It is not a clean-cut hole with sharp edges. The margins of the opening are separated by a considerable interval from the circumference of the urethra, and are prolonged over the bulb of the penis so

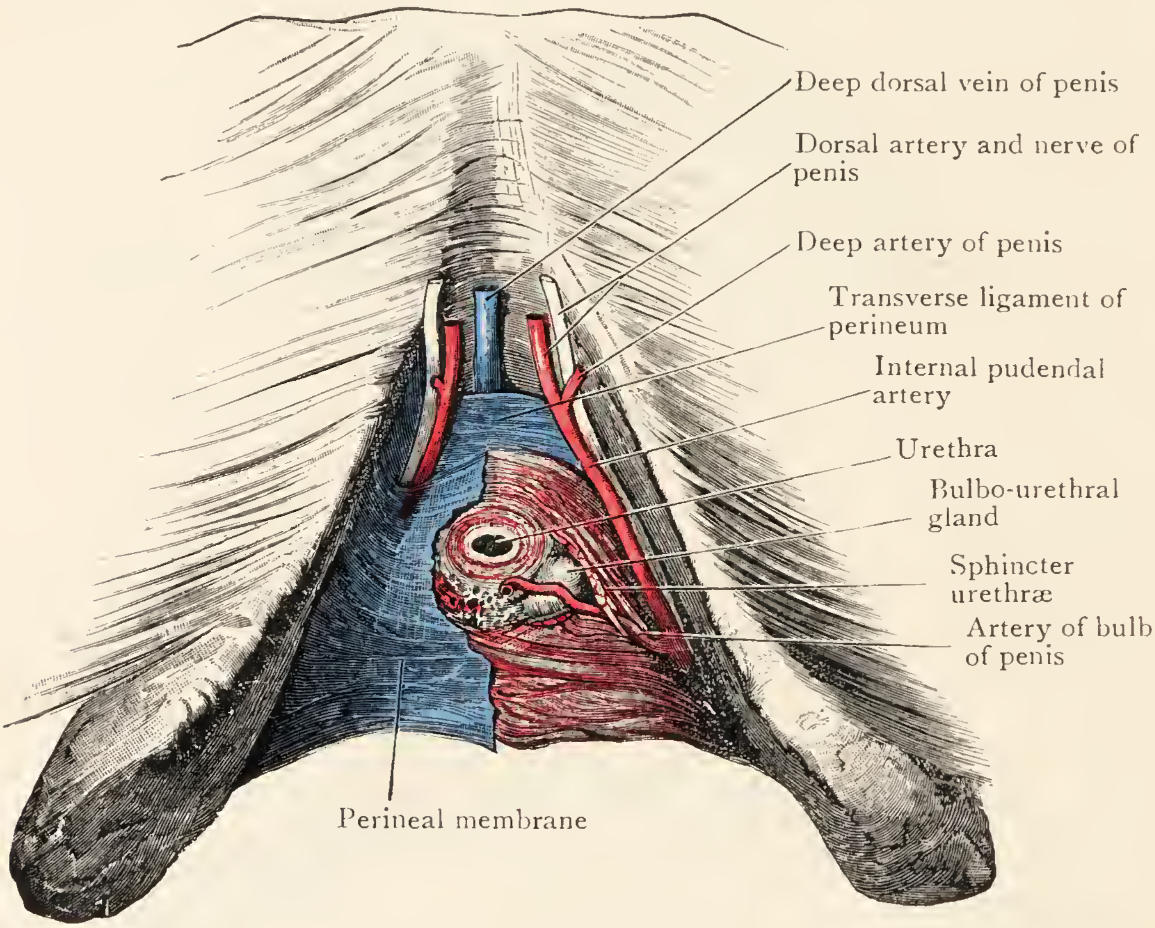


FIG. 87.—Deep Dissection of Perineum. The penis has been removed, the urethra cut across, and the left half of the perineal membrane removed.

as to form for it a fibrous capsule. After the urethra passes through the membrane it sinks into the bulb, and runs forwards through the entire length of the corpus spongiosum to its external opening on the glans penis. On each side of the urethral aperture there is a small opening in the membrane which gives passage to the corresponding *artery of the bulb*. Half an inch farther forwards the *dorsal nerve of the penis* and the *internal pudendal artery* (or its two terminal branches) pierce the membrane on each side, close to the margin of the pubic arch, and under cover of the crus penis.

Deep Perineal Pouch.—Deep to the perineal membrane, as already explained, there is a space limited internally by a layer of the fascia of the pelvis that stretches across the pubic arch above the sphincter urethræ and the deep transversus muscles. This layer is attached to the obturator fascia on each side, and it has been noted already that it is blended with the anterior and posterior borders of the perineal membrane. The pouch, thus completely enclosed, contains the following structures :—

1. Membranous part of urethra.
2. Sphincter urethræ and deep transversus perinei muscles.
3. A pair of bulbo-urethral glands.
4. Internal pudendal vessels, and vessels of the bulb.
5. Dorsal nerves of penis.

Dissection.—To expose these structures, reflect the *perineal membrane* on the side from which the crus penis was removed, but carefully preserve it on the opposite side, in order that it may serve as a landmark in the subsequent dissection of the pelvis. Detach the membrane from the side of the pubic arch, cautiously remove it from the structures above it, and throw it medially towards the bulb.

The muscles that come into view are small and difficult to dissect, but make an attempt to clean and define them.

Follow the internal pudendal artery (Fig. 87) forwards to its termination, and clean the *dorsal nerve of the penis*, which lies lateral to the artery. Next, secure the artery to the bulb, and look for the *bulbo-urethral gland*, which lies a little behind and lateral to the urethra, under cover of the deep transverse muscle.

Membranous Part of Urethra.—Now that the perineal membrane is removed on one side, the students can readily feel the staff as it lies in the membranous part of the urethra. They should examine also its surroundings. The membranous part is the shortest division of the urethra, being rather less than half an inch in length. It is about one inch distant from the pubic symphysis, and is enveloped by the fibres of the sphincter urethræ muscle. Behind it, there is a pair of small bodies called the bulbo-urethral glands.

Deep Transversus Perinei and Sphincter Urethræ.—The *deep transversus perinei* is a small muscle that springs from the junction of the pubic and ischial rami, and unites with its fellow in a median raphe, below and behind the membranous part of the urethra ; its anterior border is partly blended with the external layer of the sphincter urethræ.

The *sphincter urethræ* is divided into internal and external groups of fibres. The internal group is formed of circular fibres which embrace the membranous part of the urethra. The fibres of the external group are transverse, and arise, together with the deep transversus perinei, from the margin of the pubic arch. As they approach the median plane some of the fibres pass behind the membranous part of the urethra

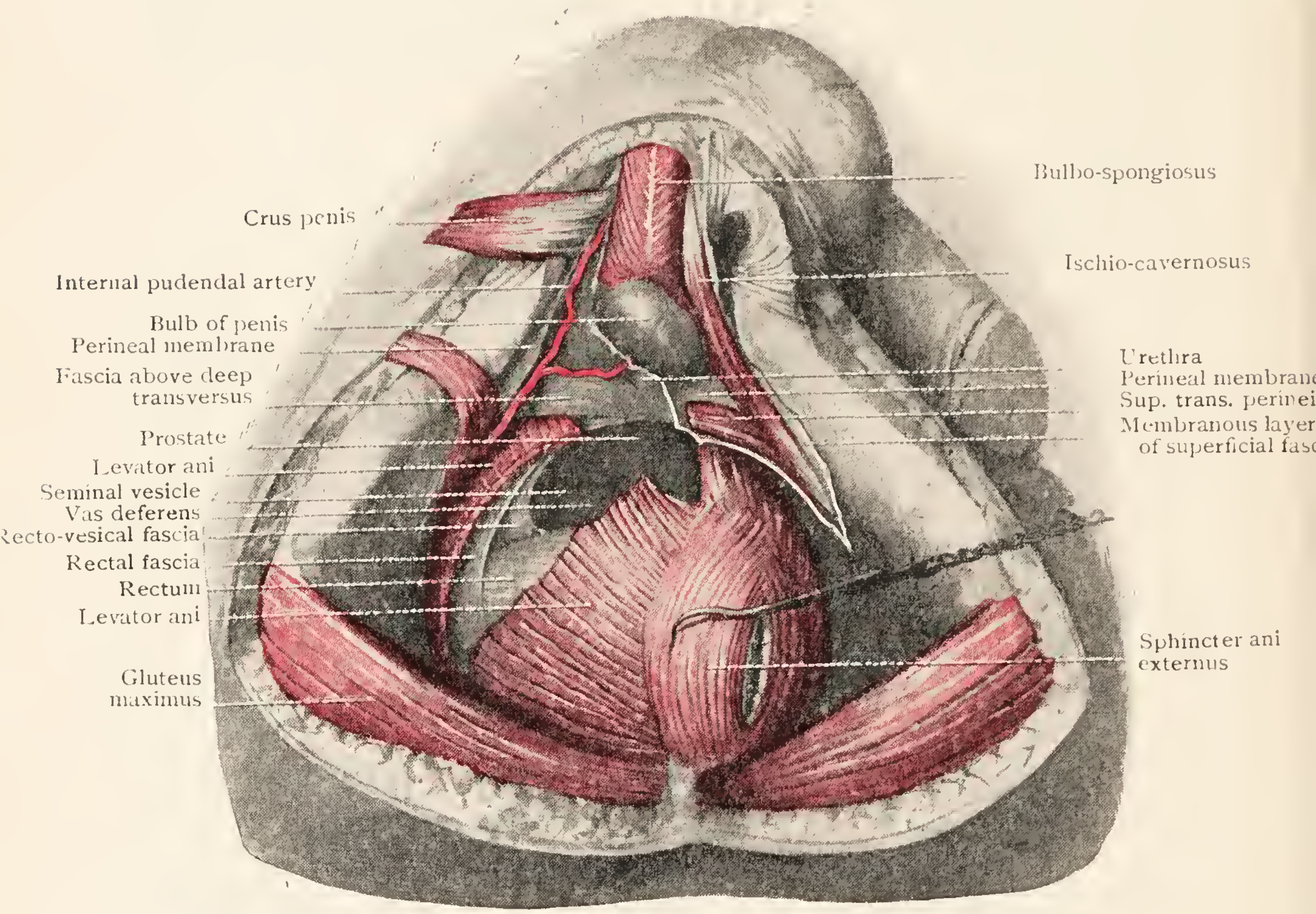


FIG. 88.—Dissection to expose the Prostate from the Perineum.

and some in front of it, and they blend with the corresponding fibres of the opposite side.

Both muscles are supplied by one or two delicate twigs from the *perineal nerve.*

Internal Pudendal Artery.—The internal pudendal artery is a branch of the internal iliac. It is met with in three different regions of the body—viz., in the pelvis; in the gluteal region; and in the perineum—and is accompanied throughout by two veins.

From the gluteal region, it passes through the lesser sciatic foramen into the perineum, and at once enters the pudendal canal on the side wall of the ischio-rectal fossa, where it is at first very deeply placed—about an inch and a half above the lower end of the ischium. It runs forwards and downwards in the canal, with the perineal nerve below it and the dorsal nerve of the penis above it ; and, reaching the posterior border of the perineal membrane, it passes above that border into the deep perineal pouch. In the pouch, it runs forwards close to the side of the pubic arch, with the dorsal nerve between it and the bone. About half an inch from the symphysis, it pierces the perineal membrane, and ends at once, under cover of the crus penis, by dividing into the deep artery and the dorsal artery of the penis (Fig. 87). In not a few cases it divides while still in the pouch, and its two terminal branches then pierce the perineal membrane separately.

Branches.—These are :—inferior rectal (p. 157), scrotal (p. 158), artery of the bulb, and two terminal branches.

The *artery of the bulb* is a short, wide vessel which arises in the posterior part of the deep perineal pouch, and runs medially below the sphincter urethræ ; it gives a small twig to the bulbo-urethral gland, and then pierces the perineal membrane, enters the bulb of the penis at once, and runs onwards through the whole length of the corpus spongiosum, supplying its substance (Figs. 87, 112).

The *deep artery of the penis*, immediately after its origin, pierces the medial side of the crus penis, and is carried forwards in the substance of the corpus cavernosum, supplying it (Figs. 101, 112).

The *dorsal artery of the penis* runs upwards between the bone and the commencement of the crus to gain the dorsum of the penis, where it will be traced later.

Pudendal Nerve.—The pudendal nerve is a terminal branch of the sacral plexus, and derives its fibres from the second, third and fourth sacral nerves. It leaves the pelvis through the lower part of the greater sciatic foramen to enter the gluteal region, where it descends across the back of the sacro-spinous ligament. It passes from the gluteal region through the lesser sciatic foramen into the perineum to enter the posterior end of the pudendal canal, where, almost at once, it gives off the inferior hæmorrhoidal nerve and divides into the perineal nerve and the dorsal nerve of the penis.

The *inferior hæmorrhoidal nerve* and the *perineal nerve* have been studied already (pp. 157, 162).

The *dorsal nerve of the penis* runs first in the pudendal canal above the internal pudendal artery, and then in the deep perineal pouch, where it lies more completely under shelter of the side of the pubic arch than the internal pudendal artery. It then pierces the perineal membrane, about half an inch from the pubic symphysis, and finally passes upwards between the bone and the crus penis to reach the dorsum of the penis along the lateral side of the dorsal artery. At the root of the penis it supplies one or two twigs to the corpus cavernosum.

Bulbo-Urethral Glands.—To find the bulbo-urethral glands raise the posterior fibres of the sphincter urethræ. They are small lobulated bodies of a deep yellow colour, and resemble small peas both in size and in shape. They are placed, one on each side of the median plane, immediately behind the membranous part of the urethra. Each gland has a very delicate and relatively long duct, which it is difficult to find. The duct does not open into the membranous part of the urethra, but passes forwards at the side of the urethra, through the perineal membrane, to open into the floor of the spongy part of the urethra one inch beyond the membrane (Figs. 231 and 234).

Lymph-Vessels of Perineum.—These vessels, like lymph-vessels elsewhere, are exceedingly slender, and cannot be displayed in an ordinary dissection; but they are present in great numbers, and the dissectors should remember that the greater part of the lymph from the perineal region is eventually discharged into the superficial inguinal lymph-glands, which lie in the superficial fascia in the upper part of the front of the thigh. It is often the enlargement of these glands that gives the first intimation of the spread of infection from the region. They receive lymph *in both sexes* from (1) the skin, fasciæ, and muscles of the perineum, and (2) from the terminal part of the anal canal; *in the male* (3) from the skin of the scrotum, penis, and pubic region, (4) from the body and root of the penis, and the spongy part of the urethra; *in the female* (5) from the external genital organs. (See p. 177 and Fig. 219, p. 444.)

Approach to Prostate.—The dissection of the male perineum, to the extent usually possible in three days, is now completed, and the students should revise their knowledge of the arrangement and contents of the two perineal pouches.

They should note also that above the upper wall of the deep pouch there are the prostate and the anterior borders of the two levatores ani; and to reach the prostate through the urogenital triangle (Fig. 88), they would have to divide a series of alternating fascial and muscular strata, viz.:—

1. The superficial fascia.
2. The superficial perineal muscles.
3. The perineal membrane.
4. The sphincter urethræ and the deep transversus perinei muscles.
5. A sheet of fascia on the pelvic surface of those muscles.

Dissection.—**Soak a pad of tow in preservative mixture, place it in the perineum, and stitch the flaps of skin over it.**

On the *fourth day* after the body has been brought into the dissecting-room, it is placed on its back, with the thorax and pelvis supported on blocks; and the dissectors of the Abdomen begin work on the abdominal wall (p. 177).

Urogenital Triangle in the Female

In the urogenital triangle, the first structures encountered are the *contents of the superficial perineal pouch.* These are:—the superficial perineal muscles, vessels and nerves, the bulbs of the vestibule, the crura of the clitoris, and the greater vestibular glands.

Superficial Perineal Vessels and Nerves.—Under this heading are included:—

Arteries	Labial branches of internal pudendal artery. Transverse perineal artery.
Nerves	Labial branches of perineal nerve. Perineal branch of posterior cutaneous nerve of thigh.

Dissection.—**The** *labial nerves and arteries* **have already been secured in the anterior part of the ischio-rectal fossa. Now, follow them forwards to the labium. Find also the** *perineal branch of the posterior cutaneous nerve of the thigh* **a little in front of the ischial tuberosity, and trace it to the labium majus.**

Two **labial nerves**—a lateral and a medial—arise from the perineal nerve in the anterior part of the pudendal canal, and pierce its medial wall to enter the anterior part of the ischio-rectal fossa; then, bending forwards, they pierce the deep layer of the superficial fascia, pass above or below the superficial transverse muscle, and end in the skin of the labium majus.

Two **labial arteries** arise in the pudendal canal from the internal pudendal artery. They accompany the nerves; and one of them sends a *transverse perineal branch* medially along the superficial transverse muscle.

The **perineal branch of the posterior cutaneous nerve of the thigh** pierces the deep fascia in front of the ischial tuberosity; it turns medially to enter the perineum, and then runs forwards to the skin of the labium majus.

Superficial Perineal Muscles.—The next step in the dissection is the exposure of the superficial perineal muscles. Before the dissectors begin to clean them, they will turn to Fig. 90 and note the following particulars:—(1) A fibrous sheet called the *perineal membrane* stretches across the pubic arch; it is interrupted in the middle by the passage of the vagina; and the middle part of its posterior border is thickened and juts backwards to join a fibro-muscular mass called the *perineal body.* (2) A pair of pear-shaped, spongy, vascular bodies lie on the lower surface of the membrane, at the sides of the opening of the vagina. They are called the *bulbs of the vestibule*, and correspond to the two halves of the bulb of the penis. (3) At the lower part of the symphysis, the body of the clitoris thickens and widens and divides into a pair of *crura*, which diverge to lie along the margins of the pubic arch on the lower surface of the perineal membrane.

Now, compare Fig. 90 with Fig. 89, in which the three pairs of superficial perineal muscles are depicted, and note the position of those muscles:—The *superficial transversus perinei* lies on the posterior border of the perineal membrane, the *ischio-cavernosus* on the crus of the clitoris, and the *bulbo-spongiosus* on the bulb of the vestibule. Their positions should be carefully studied, but their attachments, which will be examined after they are cleaned, are not important. They are supplied by twigs from the perineal nerve; and, besides the membranous layer of superficial fascia, which provides a common covering for them all, each is clothed with a delicate layer of deep fascia.

> ***Dissection.***—Divide the labial nerves and vessels near their terminations and turn them aside; then, clean the *superficial perineal muscles*, and secure the nerve-twigs that supply them.

The **superficial transversus perinei** muscle in the female is pale, and it is generally very difficult to define it. It is a slender fasciculus which takes origin from the ramus of the ischium close to the tuberosity, and passes medially to its insertion into the perineal body.

The **ischio-cavernosus** is smaller than the corresponding muscle in the male. It arises from the ramus of the ischium close to the tuberosity, and is inserted by a tendinous expansion on the surface of the crus of the clitoris.

The right and left **bulbo-spongiosus** act together functionally as a sphincter muscle of the vagina. Each is placed at the side of the vestibule, closely adapted to the surface of the bulb of the vestibule. Posteriorly, the fibres of opposite sides unite behind the vaginal opening, and are attached to the perineal body. Anteriorly, the two muscles become narrower and, converging towards the median plane, are attached to the sides of the clitoris. In some cases a small fasciculus, on each side, reaches the dorsum of the clitoris and there gains insertion into a tendinous expansion which lies superficial to the dorsal vein. That fasciculus is comparable to the fibres of the bulbo-spongiosus of the male which embrace the body of the penis (see p. 161).

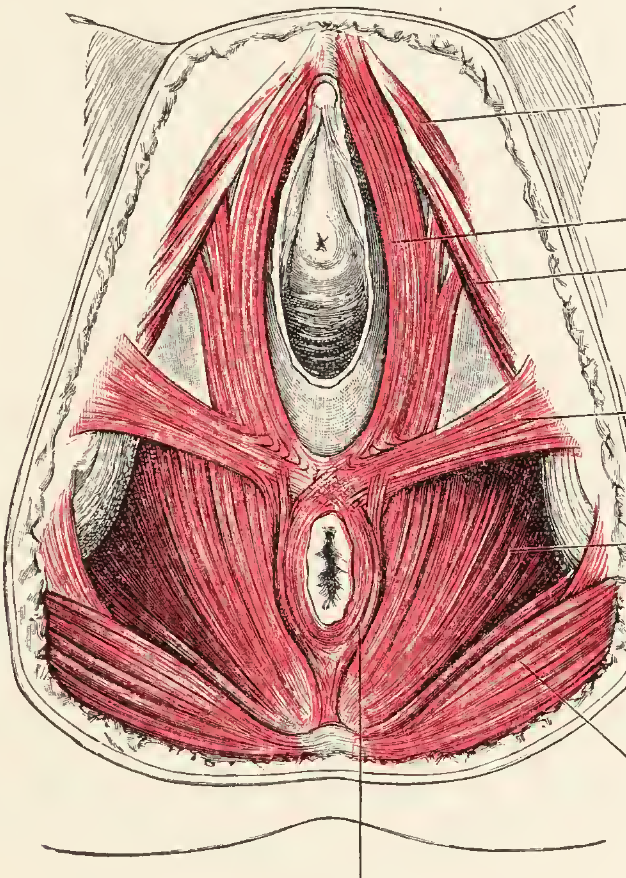


FIG. 89.—Muscles of Female Perineum. (Peter Thompson)

The **perineal body** is the indefinite mass of fibrous and muscular tissue which occupies the interval between the anal canal and the vagina. The muscular tissue belongs to the sphincter ani externus, the levatores ani, the bulbo-spongiosus and the superficial transversus perinei muscles.

In each half of the urogenital triangle, the three superficial muscles form the boundaries of a small triangle. Place the tip of the index finger in the triangle and push it upwards towards the pelvis. The resistance met with is due to the perineal membrane, which will be examined when the study of the contents of the superficial pouch is completed.

Dissection.—Raise the *bulbo-spongiosus* from the surface of the bulb of the vestibule, and the *ischio-cavernosus* from the surface of the crus clitoridis. Remove the *superficial transversus perinei* at the same time.

Bulbs of Vestibule.—These structures are now displayed. They are a pair of oblong bodies composed of *erectile tissue* (p. 162), placed one on each side of the vestibule and entrance to the vagina. Each is invested by a fibrous capsule which is adherent to the lower surface of the perineal membrane. It is relatively broad posteriorly, but narrows as it passes forwards, and, in front, between the urethra and the clitoris, the two bulbs are united by a venous plexus, called the *commissure of the bulbs*, which is itself connected with the glans of the clitoris by a slender band of erectile tissue. The details of these connexions are, however, seldom seen except in a specially injected part. The commissure and the band of erectile tissue correspond to the corpus spongiosum of the penis.

The posterior end of each bulb partially overlaps the greater vestibular gland; the lateral, convex surface is covered by the bulbo-spongiosus muscle; and the medial surface is in contact with the wall of the vagina at its orifice (Fig. 90).

Dissection.—If the stitches which were used to close the vestibule have not been removed, take them away now. The crura of the clitoris have already been exposed ; to display the entire clitoris, strip the skin away from its body and clear away the areolar tissue which surrounds it. Take care not to injure the dorsal vessels and nerve, and the suspensory ligament which attaches the clitoris to the front of the symphysis.

Clitoris.—The *body of the clitoris*, which is about an inch and a half long, is bent in a downward direction on itself, at the lower border of the pubic symphysis. It is a cylindrical body composed of a pair of *corpora cavernosa* partly separated by an imperfect *septum*. Anteriorly, it ends in a small, rounded tubercle named the *glans clitoridis*. The glans, however, is not structurally continuous with the body of the clitoris. It is a little mass of erectile tissue connected by a band of similar tissue with the commissure of the bulbs, and fits like a cap on the end of the body. Posteriorly, opposite the lower part of the symphysis, the corpora cavernosa separate, and diverge widely from each other to form the *crura*. Each crus is attached by its deep surface to the conjoined rami of the pubis and ischium, and is covered by the corresponding ischio-cavernosus muscle.

The clitoris, then, consists of three parts :—(1) *a glans*, connected with the commissure of the bulbs ; (2) *a body*, connected with the front of the pubic symphysis by a fibrous band called the *suspensory ligament* of the clitoris ; and (3) *a pair of crura*, attached to the sides of the pubic arch. The clitoris, therefore, closely resembles the penis, the chief differences being the diminutive size of the clitoris, the division of the bulb into separate halves, and that it is not traversed by the urethra.

An attempt should now be made to expose the greater vestibular gland and the perineal membrane.

Dissection.—Clear away the areolar tissue at the posterior end of the bulb, and expose the *greater vestibular gland.* The duct of the gland issues from the anterior part of the gland, and the posterior part of the bulb must be raised to expose it. While doing so, look for the artery of the bulb. In order to expose the *perineal membrane* more fully, detach the crus and the bulb and turn them forwards. Divide the artery of the bulb, and secure the deep artery of the clitoris as it enters the crus. Clean also the dorsal artery and nerve of the clitoris as they pass upwards from under cover of the crus.

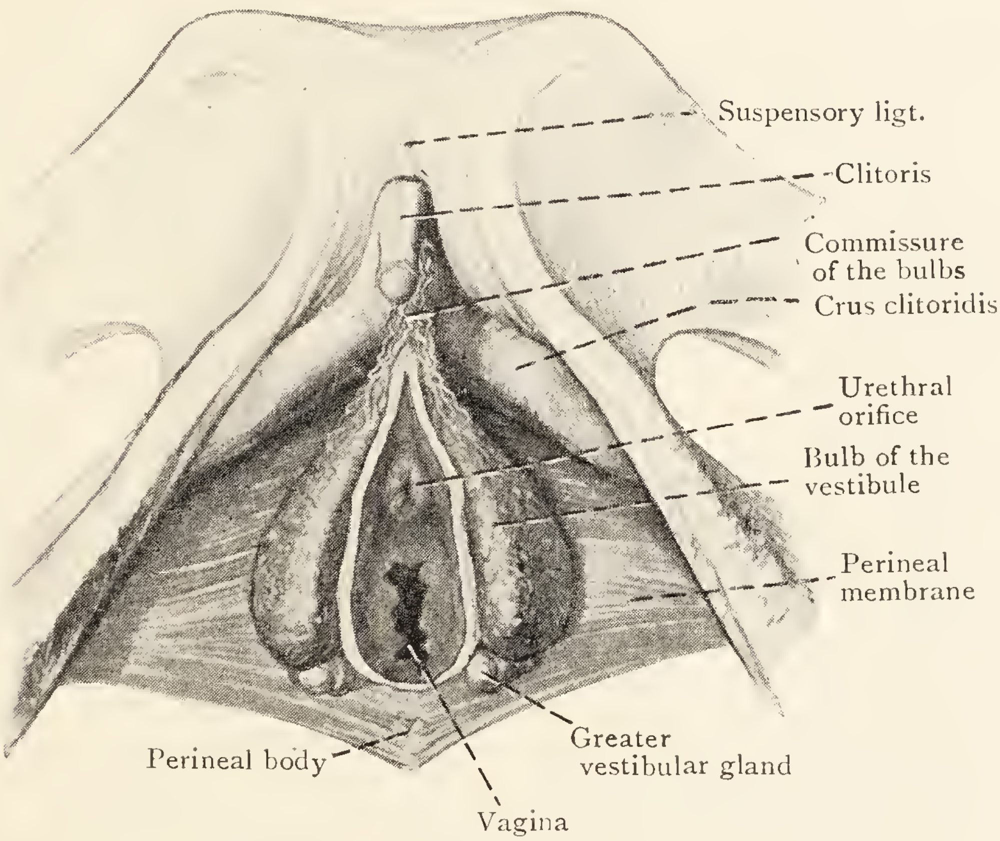


FIG. 90.—Dissection of Female Perineum to show Clitoris, Bulbs of Vestibule, and Perineal Membrane.

Greater Vestibular Glands.—This pair of glands is placed one on each side of the lower end of the vagina, largely under cover of the posterior part of the bulb of the vestibule (Fig. 90). Each is about the size of a bean, and has a long, thin *duct* which opens into the angle between the hymen and the labium minus.

Perineal Membrane.—The perineal membrane is a fibrous sheet that stretches across the pubic arch ; it is comparable to the obturator membrane, and, like it, is one of the constituents of the pelvic wall. It is wider than in the male, owing to the greater width of the pubic arch ; but it is thinner, and is also less perfect, for it is pierced by the vagina. Other structures—corresponding to those in the male—also pierce it, viz. :—(1) the urethra, immediately in front of the vagina ; (2) the artery of the bulb, near the side of the vagina ; (3) the internal pudendal vessels and the dorsal nerve of the clitoris, at the side of the pubic arch.

In the erect posture of the body, its lower surface looks directly downwards ; and each half is covered by the crus of the clitoris, the bulb of the vestibule, the greater vestibular gland, and the superficial perineal muscles. The upper surface looks towards the cavity of the pelvis, and each half is covered by a sheet of muscle partially divided into two parts—the sphincter urethræ anteriorly and the deep transversus perinei posteriorly. They, in turn, are covered with a layer of the fascia of the pelvis ; and the space between that layer and the perineal membrane is the deep perineal pouch.

Each lateral margin of the perineal membrane is attached to the side of the pubic arch. Its posterior border is fused with the posterior border of the membranous layer of the superficial fascia, and also with the fascia that clothes the deep transversus perinei ; in this way the superficial and deep perineal pouches are closed posteriorly. Its anterior border fuses with the fascia on the anterior margin of the sphincter urethræ—thus closing the deep pouch anteriorly. The fused anterior border is thickened to form a band called the *transverse ligament of the perineum*. As in the male (Fig. 81), an oval gap separates that band from the inferior ligament of the pubis ; the dorsal vein of the clitoris passes into the pelvis through the gap.

Deep Perineal Pouch.—As stated already, this is the space between the perineal membrane and the layer of fascia which covers the pelvic surface of the sphincter and deep transversus. It is closed laterally by the attachment of that layer to the obturator fascia. The vagina and urethra descend through the pouch and divide it into two parts, each of which contains :—(1) the sphincter urethræ and deep transversus perinei ; (2) the internal pudendal vessels along the side of the pubic arch ; (3) the dorsal nerve of the clitoris, between the vessels and the bone ; and (4) the artery of the bulb running medially to pierce the perineal membrane.

Dissection.—**Reflect one half of the perineal membrane. Detach it from the margin of the pubic arch and raise it cautiously. Clean the muscular layer now exposed; follow the** *artery of the bulb* **to its origin from the** *internal pudendal artery;* **clean that artery and its terminal branches and also the** *dorsal nerve of the clitoris*, **which accompanies it.**

Urethra Muliebris.—The female urethra is about an inch and a half in length, and extends from the neck of the bladder to its orifice in the perineum. It passes downwards and forwards behind the lower half of the pubic symphysis, but it is slightly curved with the concavity forwards (Fig. 82).

In its course from the bladder, the urethra passes through the deep perineal pouch, where it is surrounded by the sphincter muscle; and, after piercing the perineal membrane, it at once opens on the surface immediately in front of the orifice of the vagina. Throughout the whole of its extent it is closely attached to the anterior wall of the vagina; and so intimate is this relation that the urethra may be said to be embedded in the wall of the vagina. The urethra will be considered again with the bladder in the dissection of the pelvis on p. 480.

Pass a staff through the urethra and trace its course to the bladder by means of the left index finger introduced into the vagina. The female urethra is very dilatable; this is worthy of note, since it is of importance in the passage of instruments for diagnostic purposes and in the removal of calculi and foreign bodies from the bladder.

Deep Transversus Perinei and Sphincter Urethræ.—The *deep transversus* is a slender slip that arises from the junction of the ischial and pubic rami, and ends medially on the lower part of the posterior wall of the vagina. Its anterior fibres blend with the sphincter urethræ. The *sphincter* is divided into an internal layer of fibres arranged circularly round the urethra, and an external layer which springs from the side of the pubic arch in front of the deep transversus. As the fibres of this layer approach the median plane some pass in front of the vagina and urethra, and others are attached to the posterior wall of the vagina. Both these muscles are supplied by twigs from the perineal nerve.

Internal Pudendal Artery.—This artery arises from the internal iliac artery, and escapes from the pelvis into the gluteal region through the lower part of the greater sciatic foramen. It then descends across the tip of the ischial spine.

and passes through the lesser sciatic foramen into the perineum. Having reached the perineum, it enters the pudendal canal at once, and runs forwards and downwards in it—above the perineal nerve and below the dorsal nerve of the clitoris. At the anterior end of the canal, it passes into the deep perineal pouch, where it runs along the side of the pubic arch, with the dorsal nerve of the clitoris between it and the bone. About half an inch behind the symphysis, it pierces the perineal membrane and ends at once, under cover of the crus of the clitoris, by dividing into the *deep* and *dorsal arteries of the clitoris*.

It is accompanied throughout by *venæ comitantes*.

Branches.—These are—inferior rectal (p. 157), labial (p. 169), artery of the bulb, and two terminal branches.

The *artery of the bulb* is a short, wide artery that arises in the deep perineal pouch. It runs medially below the sphincter urethræ, pierces the perineal membrane, and enters the bulb of the vestibule.

The *deep artery* sinks into the crus, and runs onwards in the corpus cavernosum of the clitoris.

The *dorsal artery* ascends between the bone and the crus to reach the dorsum of the clitoris.

Pudendal Nerve.—The pudendal nerve takes origin in the pelvis from the anterior primary rami of the second, third and fourth sacral nerves. It leaves the pelvis through the lower part of the greater sciatic foramen, crosses the back of the sacro-spinous ligament, and passes through the lesser sciatic foramen into the perineum, where it enters the posterior end of the pudendal canal. Almost at once, it gives off its *inferior hæmorrhoidal branch* (p. 157), and then divides into its two branches—the *perineal nerve* and the *dorsal nerve of the clitoris*.

The **perineal nerve** runs forwards in the pudendal canal below the internal pudendal artery. Near the anterior part of the canal it gives off two *labial branches* (p. 169), and soon afterwards divides into its terminal branches.

The *terminal branches* run forwards and supply the bulb of the vestibule and the muscles in the deep and superficial pouches.

The **dorsal nerve of the clitoris** runs forwards in the pudendal canal above the internal pudendal artery, and, at the anterior end of the canal, it passes with that artery into the deep perineal pouch and continues forwards along the margin of the pubic arch, giving a branch to the crus of the clitoris as it goes. About half an inch behind the apex of the arch, it pierces the perineal membrane and passes to the dorsum of the clitoris.

Dorsal Vessels and Nerves of the Clitoris.—On the dorsum of the clitoris a little dissection will display the *dorsal vein* occupying the groove in the median line, with a *dorsal artery* and *nerve* lying on each side of it. Trace the arteries and nerves forwards to their termination in the glans.

The *dorsal vein of the clitoris* corresponds to the deep dorsal vein of the penis. It takes origin in the glans, and as it proceeds backwards it receives minute superficial veins, and also tributaries from the corpora cavernosa. At the root of the clitoris it passes between the transverse ligament of the perineum and the inferior pubic ligament, and is continued upwards into the pelvis to join the plexus of veins on the wall of the vagina in the region of the neck of the bladder. It communicates also with the internal pudendal vein.

Lymph-Vessels of Perineum.—In addition to lymph-vessels from skin, fasciæ, muscles, and anal canal (see p. 168), the superficial inguinal lymph-glands receive vessels from the external genital organs and the lower end of the vagina (Fig. 219, p. 444).

The dissection of the perineum being now completed, the students should revise their knowledge of the parts displayed in the urogenital triangle, and then sew up the perineum.

Dissection.**—Place a pad of tow soaked in preservative solution in the perineum and stitch the skin flaps over it.**

On the *fourth day* after the body has been brought into the dissecting-room, it is placed on its back with the thorax and pelvis supported on blocks; and the dissectors of the Abdomen begin work on the abdominal wall.

ANTERIOR WALL OF ABDOMEN

The term "anterior wall" includes also the portion at each side between the ribs and the iliac crest.

External Anatomy.—Before the dissection of the abdominal wall is begun, some attention must be paid to the general configuration and bony prominences of the region.

If the subject is obese, the abdomen is smooth, rounded and protuberant; if it is spare, the abdominal wall is depressed and the lower margin of the thorax and the pubic and iliac crests stand out in marked relief, and a tendinous band, called the *inguinal ligament*, which stretches between these crests, may also raise a well-defined ridge. This band is the lower border of the aponeurosis of the obliquus externus, which is the outermost muscle of the anterior wall. In a muscular body, the fleshy part of the external oblique muscle bulges out over the anterior half of the iliac crest, and that part of the crest is therefore in the floor of a groove.

In the median plane, the student will notice a linear depression that extends downwards from the lower end of the sternum towards the symphysis. The depression corresponds with the position of a median fibrous band, called the *linea alba*, that lies under cover of the skin and fascia (Figs. 96, 114). The linea alba is important to the surgeon, because, being fibrous, it is practically devoid of blood-vessels; consequently, it is chosen as the region through which the trocar is introduced into the abdomen in the operation of *paracentesis abdominis* or tapping.

The *umbilicus* or *navel* is seen in the lineal depression rather nearer the pubis than the xiphoid process of the sternum. It is a depressed and puckered cicatrix, but its floor is frequently raised to form a little button-like knob. It extends into the linea alba, and is the result of the closure of the umbilical orifice which existed in the abdominal wall until birth for the passage of the constituents of the umbilical cord, viz.—the umbilical vein, a pair of umbilical arteries, and the embryonic structure called allantois and urachus (p. 467). At birth the umbilical cord is severed; thereafter, its constituent parts atrophy and are lost at the umbilicus in the fibrous scar that is formed; but their intra-abdominal portions are recognisable throughout the whole of life, and, when the abdomen is opened, they will be found as fibrous cords connected respectively with the liver, the internal iliac arteries, and the urinary bladder.

In well-developed subjects, a rectus abdominis muscle stands out on each side of the median line, forming a longitudinal prominence which is broader above than below. Its lateral margin is slightly convex, and is indicated by a groove on the skin, known as the *linea semilunaris*, which extends from the pubic tubercle to the costal margin at the ninth costal cartilage. It may be mentioned here that the rectus is incompletely enclosed in a strong sheath composed of the aponeuroses of the other muscles of the anterior wall; this sheath is examined when the muscles are dissected.

Note that the lateral margin of the rectus abdominis crosses the lower margin of the thorax at the ninth costal cartilage, and that the point of crossing, on the right side, indicates the position of the fundus or lower end of the gall-bladder (Figs. 98, 128).

After the regions of the linea alba and the linea semilunaris have been examined, place the index finger on the upper part of the pubic symphysis, and carry it laterally along the pubic crest to the pubic tubercle, which is the small prominence at the lateral end of the crest. At the pubic tubercle, the finger will enter a linear depression seen at the junction of the abdomen and the thigh; this is the groove of the groin, and it runs first sidewards and then upwards along the line of the inguinal ligament to the anterior superior iliac spine. All the parts mentioned can be felt if careful pressure is made. With the eye, gauge the position of the point on the inguinal ligament which is equidistant from the pubic symphysis and the anterior superior iliac spine. It is called the **mid-inguinal point**; behind it, the psoas major muscle escapes from the abdomen, and the external iliac artery becomes the femoral artery.

The dissectors should now endeavour to determine the position of the **superficial inguinal ring**, which is an aperture in the aponeurosis of the external oblique muscle of the abdomen (Fig. 92).

In the female, it is not easily found, for it is small, and the round ligament of the uterus, which passes through it, is too slender to be readily felt in the fat of the region, and is therefore not a guide to it as the spermatic cord is in the male. But make an attempt to find it. Place the finger-tip on the skin a little below the pubic tubercle and invaginate the skin upwards till the finger-tip is above the pubic tubercle, and then press *backwards*; in a thin body, the finger-tip will feel the margins of the ring.

In the male, it is easily found. Immediately lateral to the pubic tubercle, the thick, rounded bundle called the spermatic cord can be felt as it passes over the medial end of the inguinal ligament. Take the spermatic cord as a guide; with the finger-tip, push the loose skin of the scrotum upwards along the cord till a point immediately above the pubic tubercle is reached, and then press *backwards*; the tip of the finger will then feel distinctly the margins of the ring, for they are sharp and well-defined. The most important constituent

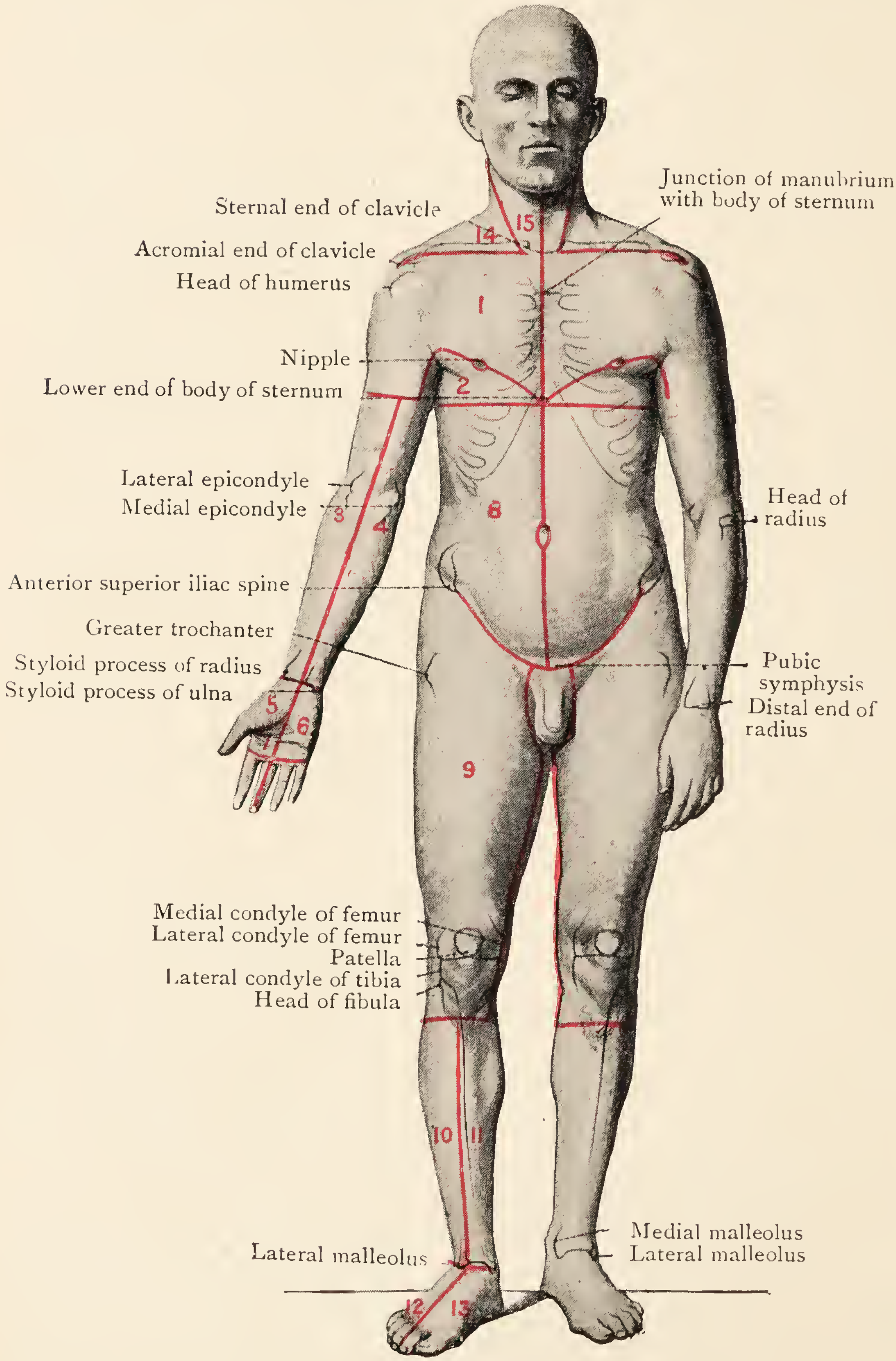


FIG. 91.—Landmarks and Incisions.

of the spermatic cord is the vas deferens, which is the duct of the testis. If the cord is rolled between finger and thumb, this duct can be easily distinguished, in the back of the cord, because it feels like a piece of whipcord.

After the inguinal region has been examined, carry the index finger backwards, from the anterior superior iliac spine, along the *iliac crest*. The crest is easily felt ; indeed, in most bodies it is visible for a distance of about two and a half inches. At the point where it disappears from view there is a swelling on its outer lip called the *tubercle of the crest*, which is a useful landmark. It is there, at the highest point of the iliac crest which can be seen from the front, that the lateral outline of the trunk joins the ilium. As will be seen later, use is made of this fact in dividing the abdominal cavity into regions.

In women who have borne children the skin over the lower part of the abdomen is wrinkled and scarred.

Having examined the external features, the students will now proceed to dissect the anterior wall.

Parts to be dissected.—In the dissection of the anterior wall of the abdomen, the following parts will be displayed :—

1. Superficial fascia.
2. Cutaneous vessels and nerves.
3. External oblique muscle.
4. Internal oblique muscle.
5. Lower five intercostal nerves and subcostal nerve and accompanying vessels ; ilio-hypogastric and ilio-inguinal nerves.
6. Transversus abdominis muscle.
7. Rectus and pyramidalis muscles and sheath of rectus.
8. Transversalis fascia.
9. Inferior epigastric and deep circumflex iliac arteries.
10. Superior epigastric and musculo-phrenic arteries.
11. Spermatic cord or round ligament of uterus.
12. Inguinal canal.
13. Extra-peritoneal tissue and its contents.
14. Parietal peritoneum.

Dissection.—Reflexion of Skin : *Incisions* :—(1) Along the median line of the body from the xiphoid process to the pubic symphysis ; carry the knife around the navel so as to surround it with a circular incision. (2) From the xiphoid process transversely round the thorax, as far back as the knife can be carried. (3) From the pubic symphysis laterally, along the line of the inguinal ligament, to the anterior superior iliac spine, and then backwards along the iliac crest (Fig. 91).

A large flap of skin is thus mapped out ; raise it carefully from the superficial fascia and turn it aside. If the abdominal wall is flaccid, the student may facilitate the dissection by inflating the abdomen. For this purpose, make an incision through the umbilicus large enough to admit the nozzle of the bellows or an injection-pipe fixed to a bicycle-pump, and, when the walls are quite tense, secure the opening with twine, which should previously be sewn through the skin round the lips of the incision.

Superficial Fascia.—The superficial fascia presents the same appearance and possesses the same general characters as in other places. In adipose subjects, however, it may be a very thick layer loaded with fat. It is usually thinner where it is continuous with the corresponding fascia over the thorax ; below, it becomes more strongly marked, and acquires a greater density. Over the lower part of the abdomen it also develops special characters ; it is divided into two layers that correspond to those already seen in the urogenital area of the perineum—a fatty superficial layer and a membranous deep layer.

There is, however, another point in which the superficial fascia differs from the same fascia in other parts of the body. It is more elastic—the increased elasticity being due to the augmentation of the elastic fibres in its membranous layer. Over the lower part of the linea alba the elastic tissue is collected in the form of a distinct band which descends in front of the pubic symphysis to become connected with a fascial sling called the suspensory ligament of the penis or the clitoris. A reference to comparative anatomy gives interest to this fact. The elastic band in Man is the vestigial representative of a continuous and distinct layer of yellow elastic tissue (*the abdominal tunic*) found in the horse and other quadrupeds in which the weight of the viscera is sustained chiefly by the abdominal wall.

As the two layers of the superficial fascia descend from the front of the abdomen, the superficial or fatty layer passes over the inguinal ligament and becomes directly continuous with the superficial fascia on the front of the thigh.

The connexions of the deep or membranous layer are very different. In the groin, it descends over the inguinal ligament to blend with the deep fascia of the thigh immediately below that ligament. In the region of the pubes, it is carried downwards into the perineum and becomes continuous there with the membranous layer of fascia, which is attached to the sides of the pubic arch (see p. 150). It reaches the perineum in the female by passing through the mons pubis into the labia majora, and in the male by passing over the spermatic cords and penis and through the wall of the scrotum.

Dissection.—The connexions of the membranous layer of superficial fascia are so important that it is necessary to undertake a special dissection in order that they may be demonstrated. As this dissection encroaches on the thigh, it must be done in conjunction with the dissectors of the Lower Limb.

Make a transverse incision through the entire thickness of

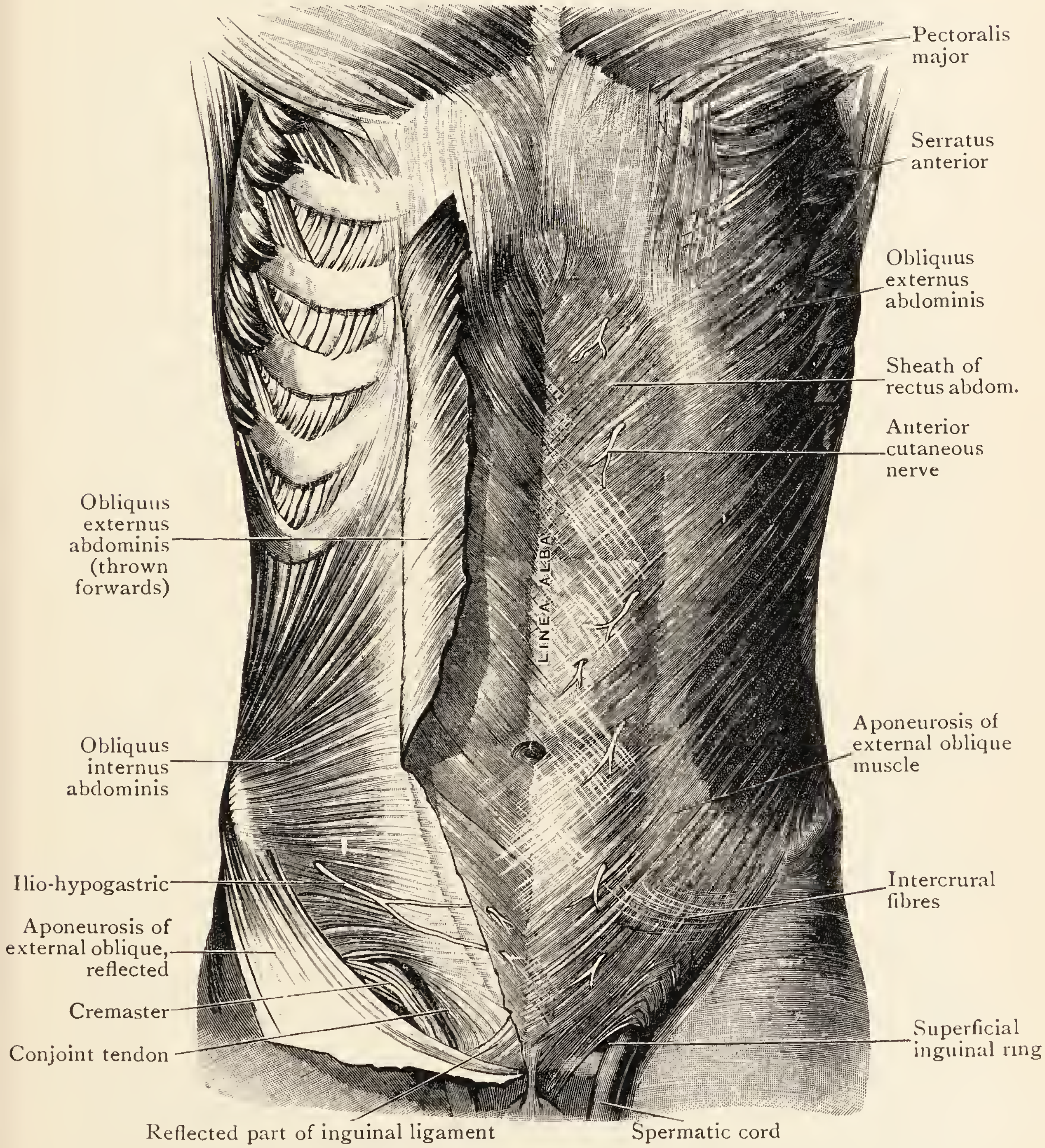


FIG. 92.—Dissection of Anterior Wall of Abdomen.
The obliquus externus abdominis has been reflected on the right side.

the superficial fascia on the front of the abdomen from the anterior superior iliac spine to the median line. When the edge of the lower part of the divided fascia is raised, the two layers can be easily distinguished. Insinuate the fingers between the membranous layer and the aponeurosis of the external oblique muscle. Little resistance will be met, as the membranous layer is bound down only by lax areolar tissue. As the superficial fascia is raised, the anterior cutaneous branch of the *ilio-hypogastric nerve* will be seen piercing the aponeurosis and entering the deep surface of the superficial fascia a little way above the superficial inguinal ring. The fingers can be readily passed downwards behind the fascia as far as the inguinal ligament. There, it will be found that they can force their way no farther. The passage of the hand into the thigh is barred by the blending of the membranous superficial fascia with the deep fascia of the thigh. Towards the pubes, however, the finger can be pushed downwards behind the fascia and along the spermatic cord (or the round ligament of the uterus) into the perineum. No barrier opposes the passage of the finger in that direction. The continuity of the membranous layers of superficial fascia on the anterior abdominal wall and in the urogenital triangle of the perineum is thus demonstrated.

If the dissectors now consider the arrangement and attachments of the membranous layer of the superficial fascia over the lower part of the anterior wall of the abdomen and in the urogenital triangle they will have no difficulty in understanding the course which urine takes when extravasated from a rupture of the male urethra below the perineal membrane. The effused fluid is directed upwards into the subcutaneous tissues of the scrotum and the penis, and along the spermatic cords to the front of the abdomen; and it mounts upwards in the abdomen because it cannot pass downwards to the front of the thighs, owing to the attachment of the membranous superficial fascia to the deep fascia of the thigh (see p. 151).

Cutaneous Nerves.—The cutaneous nerves of the anterior and lateral walls of the abdomen are arranged in an *anterior* and a *lateral series* on the same plan as the cutaneous nerves of the thorax (Fig. 2, p. 7).

The anterior series are the anterior cutaneous branches of the lower five intercostal nerves and of the subcostal and ilio-hypogastric nerves, and also the terminal part of the ilio-inguinal nerve.

The lateral series are the lateral cutaneous branches of the lower three intercostal nerves and of the subcostal and ilio-hypogastric nerves.

The *anterior cutaneous branches of the intercostal and* *subcostal nerves* are the small terminal twigs of those nerves. They pierce the anterior wall of the sheath of the rectus at variable points—some close to the median line, others a little distance from it. After entering the superficial fascia, they divide into several fine branches, some of which run for a short distance in a lateral direction.

Dissection.—To find these nerves divide the superficial fascia along the median line and reflect it cautiously. Small arteries accompany the nerves and, if injected, serve as guides.

The course of the nerves of which these are the terminal branches will be traced at a later stage in the dissection. But it should be noted now that the areas of skin supplied by successive nerves are progressively lower and lower on the anterior abdominal wall. Thus, the region of the umbilicus is supplied by the anterior cutaneous branch of the tenth thoracic nerve.

The *anterior cutaneous branch of the ilio-hypogastric* is in series with the others. When the superficial fascia was dissected it was seen piercing the aponeurosis of the external oblique a short distance above the superficial inguinal ring.

The *ilio-inguinal nerve* passes out through the superficial inguinal ring, and is distributed to the skin of the medial side of the thigh and of the scrotum or the labium majus.

Dissection.—To display the lateral cutaneous nerves, cut through the superficial fascia along the posterior axillary line down to the iliac crest ; reflect the anterior part of the fascia forwards and secure the nerves as they emerge from between the slips of origin of the external oblique muscle.

The *lateral cutaneous branches of the lower intercostal nerves* become superficial between the slips of origin of the external oblique muscle, and each then divides into an anterior and posterior division. The *posterior divisions* are small, and are directed backwards over the latissimus dorsi. The *anterior divisions* supply the external oblique muscle and then run forwards ; and a careful dissector may trace them as far as the lateral margin of the rectus abdominis.

The *lateral cutaneous branch of the subcostal nerve* differs from the other members of the series. It does not divide, and it descends to supply the skin of the gluteal region. It pierces the external oblique muscle in a line with the other lateral nerves, and then descends across the iliac crest one or two inches behind the anterior superior spine.

The *lateral cutaneous branch of the ilio-hypogastric nerve* also is distributed to the skin of the gluteal region. It pierces the external oblique immediately above the iliac crest and descends over the tubercle of the crest.

Cutaneous Arteries.—Some of the cutaneous arteries accompany the cutaneous nerves. Those which are associated with the lateral cutaneous nerves are branches of the *posterior intercostal arteries*, whilst those in relation to the anterior cutaneous nerves are derived from the *superior* and *inferior epigastric arteries.*

In addition, *three* small branches of the femoral artery ramify in the superficial fascia of the groin.

These are :—

1. Superficial external pudendal.
2. Superficial epigastric.
3. Superficial circumflex iliac.

They take origin from the femoral artery a short distance below the inguinal ligament, and, after piercing the overlying deep fascia, they diverge from each other in the superficial fascia.

The *superficial external pudendal artery* is directed medially in front of the spermatic cord or the round ligament of the uterus. It gives branches to the skin of the scrotum and inferior surface of the penis, or, in the female, to the labium majus.

The *superficial circumflex iliac artery* passes laterally and upwards, along the line of the inguinal ligament, and ends in the skin over the anterior superior iliac spine.

The *superficial epigastric artery* takes a course upwards and medially, and, after crossing the inguinal ligament, it ramifies in the superficial fascia over the lower part of the abdomen. Its branches extend as high as the level of the umbilicus.

The *veins* that accompany these arteries open into the long saphenous vein (Fig. 94).

Muscles of Anterior Wall of Abdomen.—The structures of the anterior wall include *five pairs of muscles* and the aponeuroses which constitute the tendons of three of them.

Anteriorly, there are the rectus and pyramidalis muscles. The rectus is placed alongside the linea alba, and extends vertically from the pubic bone to the lower part of the thorax ;

the pyramidalis is a small muscle that lies on the front of the lowest part of the rectus. *At the side*, three fleshy and aponeurotic strata are met with. From the surface inwards they are :—(1) the obliquus externus ; (2) the obliquus internus ; (3) the transversus. The direction taken by the muscular fibres which compose each of the layers is different. The external oblique corresponds in direction with the external intercostal muscles : the fibres proceed obliquely downwards and forwards. The internal oblique resembles the internal intercostal muscles in the direction of its fibres : most of them are directed upwards and forwards. Thus, the fibres of the two oblique muscles cross each other like the limbs of the letter X. Lastly, most of the fibres of the transverse muscle pursue a horizontal course.

The difference of direction of the fibres is a source of strength to the abdominal wall ; and the arrangement offers a strong barrier to the protrusion of any of the abdominal contents. The two oblique muscles and the transversus are continued to the median line in the form of aponeuroses. The union of the aponeuroses of the opposite sides forms the *linea alba*—a strong, fibrous median band which extends from the pubic symphysis to the xiphoid process, and will be studied later (p. 202).

FIG. 93.—Iliac Crest as seen from above (semi-diagrammatic), with Attachments of Muscles mapped out.

Dissection.—Remove the superficial fascia and clean the aponeurosis of the external oblique muscle. Near the thorax this aponeurosis is very thin, and is liable to injury. Proceed cautiously also at the lower part of the abdomen above the medial end of the inguinal ligament. There, the aponeurosis is pierced by the spermatic cord in the male and by the round ligament of the uterus in the female. The lips of the opening thus formed are prolonged downwards upon the cord (or the ligament) in the form of a thin tubular membrane called the *external spermatic fascia.* In defining this fascia, do not use the blade of the knife : work entirely with the handle.

Next, clean the muscular part of the external oblique. The most convenient way to clean the muscle is to incise the fascia over the posterior part of the muscle along a line at right angles to the fibres, and to reflect the fascia forwards. At the anterior part of the muscle the deep fascia blends with the aponeurosis, which must not be injured. Finish the cleaning of the muscle by carefully defining the slips of origin from the lower eight ribs.

Obliquus Externus Abdominis.—The external oblique muscle arises from the outer surfaces and lower borders of the lower eight ribs by *eight* pointed slips or digitations which interdigitate with the slips of origin of the serratus anterior and latissimus dorsi. The fibres proceed downwards and forwards with varying degrees of obliquity. The *lower* or *posterior fibres* have a nearly vertical direction; the *upper fibres* are almost horizontal; and the *middle fibres* are oblique. The lower fibres are inserted, as fleshy fibres, into the anterior half of the outer lip of the iliac crest; they provide the muscle with a free posterior border which stretches from the last rib to the middle of the crest and will be examined when the body is turned face downwards. All the upper and middle fibres end in a strong *aponeurosis*.

The *upper part* of the aponeurosis passes medially to be attached to the xiphoid process; it is from that part of the aponeurosis that the pectoralis major derives fibres of origin. The *lower border* of the aponeurosis is folded upon itself to form the inguinal ligament, which stretches from the anterior superior iliac spine to the pubic tubercle. *Between the upper and lower attachments*, the aponeurosis lies in front of the rectus, taking part in the formation of its sheath; and it is inserted into the linea alba and into the front of the pubic bone and symphysis—the lowest fibres crossing to the opposite pubic bone and decussating with their fellows of the other side at the median plane (Fig. 95).

The aponeurosis is broadest and strongest inferiorly; it is narrowest about the level of the umbilicus, for it again widens slightly towards the ribs. Its uppermost part is so thin that the fibres of the rectus shine through it (Fig. 92).

Superficial Inguinal Ring (Figs. 92, 94 and 95).—The aponeurosis of the external oblique is pierced, immediately above the pubis, by the spermatic cord in the male and by the round ligament of the uterus in the female. The aperture thus made receives the name of the *superficial inguinal ring*. At the present stage of the dissection the opening is not visible, because a thin tubular covering is carried downwards from its lips around the spermatic cord or the round ligament. This covering is called the **external spermatic fascia**. *In the female* it is very short and ill-defined, for it is soon lost by blending with the round ligament. *In the male* it is a wide tube prolonged downwards around the cord into the scrotum. When the cord is raised and made tense, it is obvious that the covering invests it completely, and that it is funnel-shaped near the ring—wide above, but closing upon the cord as it is traced downwards.

Dissection.—**With the point of the knife, divide the external spermatic fascia around the cord or the round ligament, and, with the handle, define the margins of the ring.**

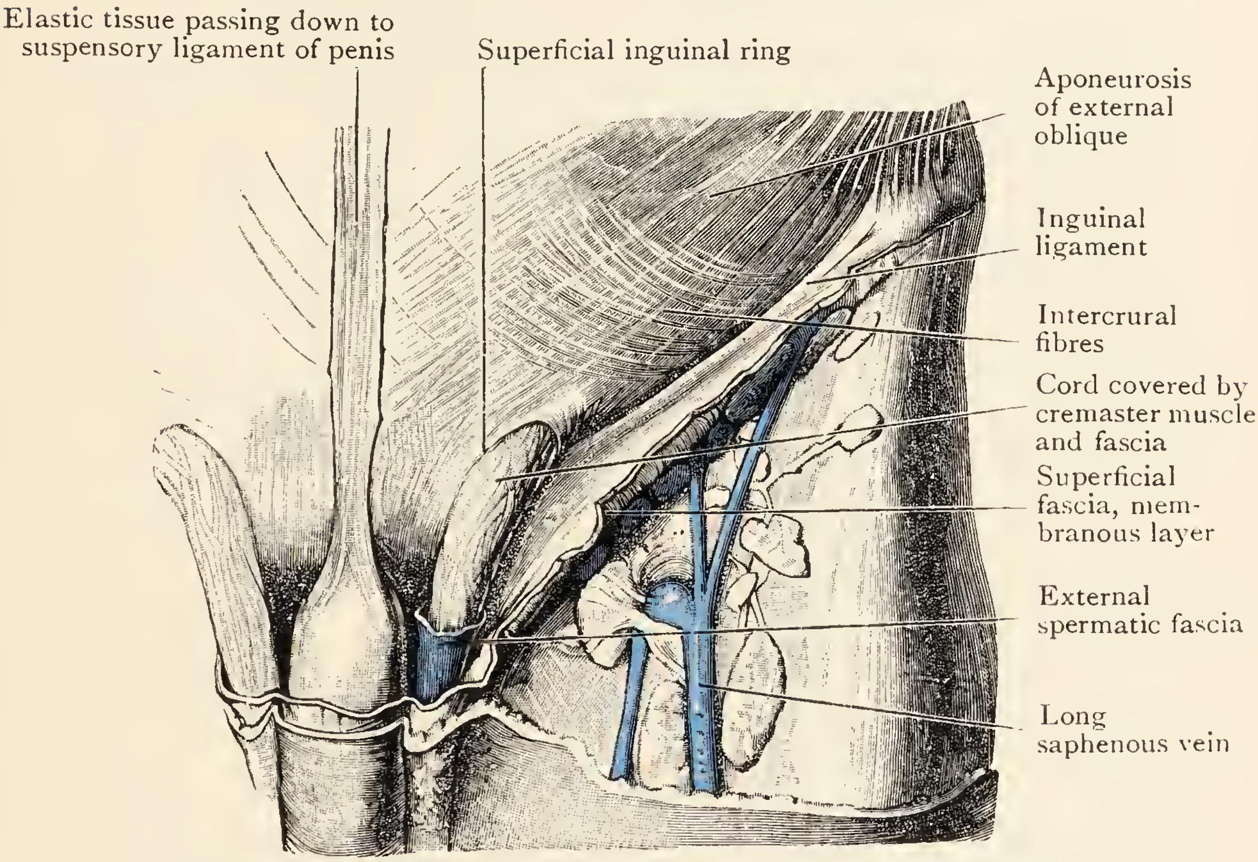


FIG. 94.—Dissection of Superficial Inguinal Ring and the parts in its vicinity.

When the definition is completed, the dissectors will note that the term " ring " is apt to convey an erroneous impression, for the opening is triangular rather than circular. Its long axis is very oblique, the base of the triangle being at the pubic crest and the apex pointing sidewards and upwards.

The margins of the aperture are termed the *crura of the ring*. The *superior crus* is flat and broad, and is attached to the body of the pubis. The *inferior crus* is curved, for the spermatic cord (or the round ligament), as it issues from the ring, rests upon the medial part of the crus; that part of the crus is thick and strong, and, as it is the medial part of the inguinal ligament, it is fixed to the pubic tubercle.

The *size* of the superficial inguinal ring is very variable; but usually, in a man, it can barely admit the finger-tip. In

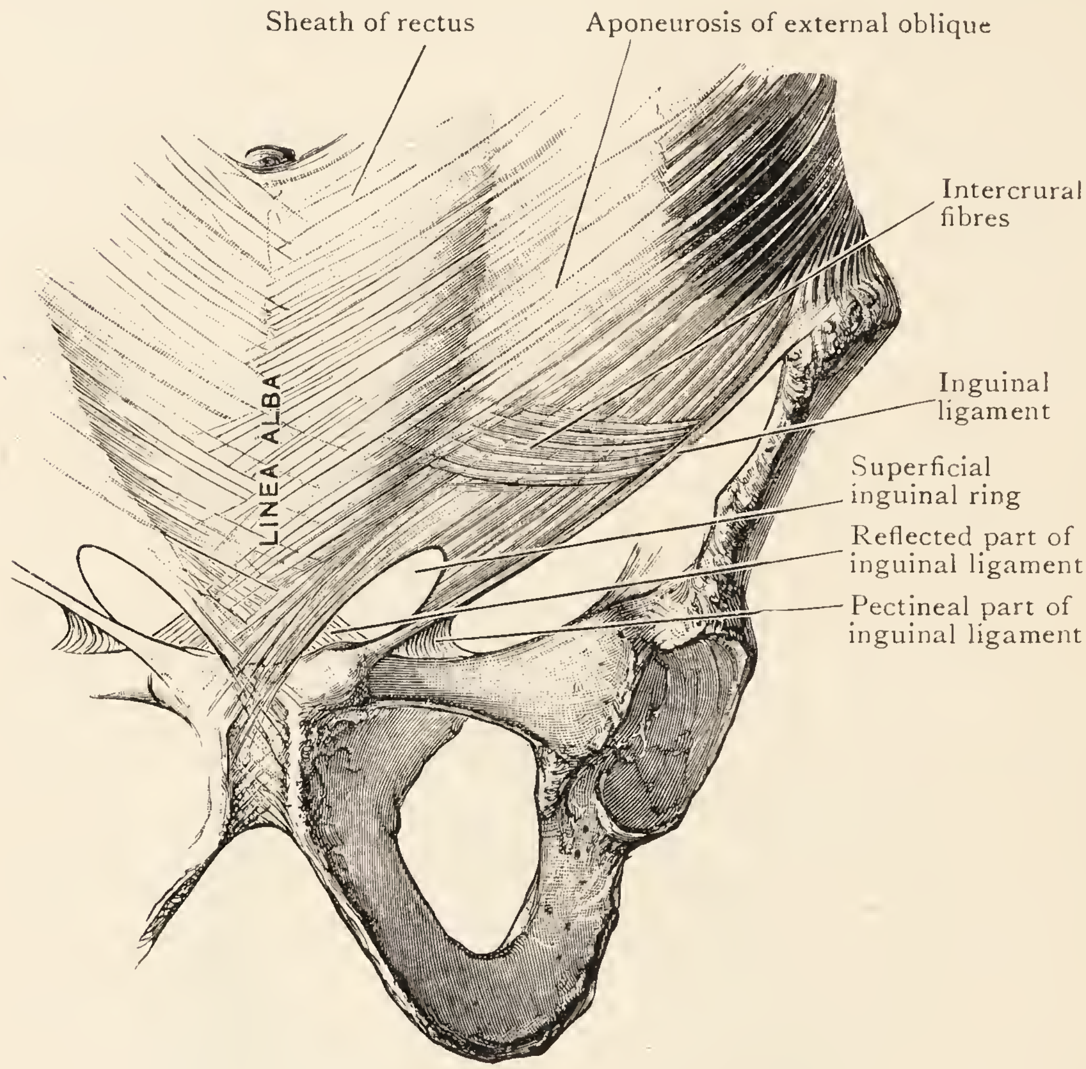


FIG. 95.—Dissection to show the connexions of lower part of Aponeurosis of External Oblique Muscle.

women, it is much smaller, for the round ligament of the uterus is only a fraction of the thickness of the spermatic cord.

On a close inspection of the lower part of the external oblique aponeurosis, the students will see a number of cross-fibres arching over its surface. They are called the *intercrural fibres*, and sometimes are very strongly marked (Fig. 94). They begin at the inguinal ligament, close to the anterior iliac spine, and curve medially and upwards, on the aponeurosis, above the superficial inguinal ring. The function of these fibres is very evident, and the term "*intercrural*" is derived from the part which they play. They bind together the two crura of the ring, and prevent their further separation. There is a direct continuity between the intercrural fibres and the external spermatic fascia.

The next dissection is the reflexion of the obliquus externus; but the dissectors of the **female abdomen** will first trace the *round ligament of the uterus* downwards amidst the fat to its termination. They will find that it breaks up into a number of thin bundles that partly are lost in the superficial fascia of the labium majus and partly attach themselves to the skin of the labium.

Dissection.—**Reflexion of Obliquus Externus.** Leave the lower two slips of origin untouched, in order that the posterior border may be examined when the body is turned. Detach the upper six slips from the ribs ; and, from the interval between the sixth and seventh slips, carry an incision downwards through the muscle to the posterior part of the tubercle of the iliac crest. Raise the anterior portion of the muscle and turn it medially, dividing the fleshy fibres inserted into the iliac crest close to the bone. Next, divide the aponeurosis horizontally in a line leading from the anterior superior spine to the lateral border of the rectus. The greater part of the external oblique can now be thrown forwards. Proceed with care on approaching the lateral border of the rectus, because a little beyond that border the anterior lamella of the aponeurosis of the internal oblique fuses with the aponeurosis of the external oblique. Define the line of union, and notice that it does not extend beyond the lower margin of the thorax.

On the *left side* of the body, the parts below the horizontal line drawn from the anterior superior iliac spine should be preserved intact for the special study of the structures associated with inguinal hernia. On the *right side* of the body, divide the lower part of the aponeurosis along the lateral border of the rectus down to the pubis. The incision should pass to the medial side of the superior crus of the superficial inguinal ring, in order that that opening may be preserved. Throw the flap of aponeurosis downwards and laterally. By this proceeding, the inguinal ligament, the internal oblique muscle and the cremaster muscle are displayed for study.

Inguinal Ligament.—This important band is the lower border of the aponeurosis of the external oblique muscle thickened and folded backwards upon itself. It thus presents a rounded surface towards the thigh and a grooved surface towards the abdomen—fibres of the internal oblique and transverse muscles taking origin from the floor of the groove. The manner in which it is attached by its lateral and medial extremities deserves the close study of the dissectors. *Laterally* it is fixed to the anterior superior iliac spine ;

medially it has a double attachment, viz. :—(1) to the pubic tubercle, which is its attachment proper; (2) to the pectineal line through the medium of its *pectineal part*.

The inguinal ligament does not pursue a straight course between its iliac and pubic attachments. It describes a curve which is convex towards the thigh—first descending fairly steeply from the iliac spine and then turning medially to end on the pubis. Its lower border gives attachment to the deep fascia of the thigh, which, by its tension on the ligament, maintains the curvature; when the fascia is incised, the ligament at once loses its curved direction.

The **pectineal part of the inguinal ligament** (lig. lacunare) (Fig. 95) is a triangular expansion from the medial part of the inguinal ligament. Raise the spermatic cord (or the round ligament), place the finger behind the medial part of the inguinal ligament, and press downwards. The structure upon which the finger rests is the pectineal part of the ligament, and the student should note that it offers a barrier to the passage of the finger into the thigh. With the handle of the knife, its shape and connexions can be easily defined. Its *apex* is fixed to the pubic tubercle; by *one margin* it is continuous with the inguinal ligament; by its *other margin* it is inserted for the distance of an inch into the pectineal line. Its *base* is sharp, crescentic, and free, and is directed laterally towards the femoral sheath (p. 241). It occupies an oblique plane—its femoral surface looking downwards and slightly forwards, its abdominal surface upwards and slightly backwards.

The dissectors should thoroughly realise that it is not an independent structure. It is merely the medial part of the folded-back margin of the inguinal ligament which, in the vicinity of the pubis, obtains an attachment to bone. They should note also that it forms part of the floor of a groove in which the spermatic cord or the round ligament lies.

The **reflected part of the inguinal ligament** is seldom sufficiently developed to merit the attention of the dissectors, but occasionally it is in the form of a well-defined, flat, triangular band. It consists of fibres reflected from the pubic attachments of the inguinal ligament. They run upwards and medially behind the spermatic cord and the superior crus of the ring, pass through the linea alba, and mingle with the fibres of the external oblique aponeurosis of the other side (Fig. 95).

Pectineal Ligament.—This should not be confused with the pectineal part of the inguinal ligament though they are closely connected. It is a strong ridge of fibrous tissue that extends along the pectineal line from the pectineal part of the inguinal ligament; and it serves as a mooring for sutures in surgical operations in this region.

Dissection.—Clean the upper part of the left *internal oblique muscle* and the whole of the right muscle, preserving and tracing the nerves that pierce it—at the anterior part of the iliac crest and above the lateral part of the inguinal ligament.

When defining the lower margin of the right muscle, note its relation to the round ligament of the uterus, or, if it is a male body, do not disturb its relations to the spermatic cord, and preserve the muscular fasciculi which form the cremaster muscle.

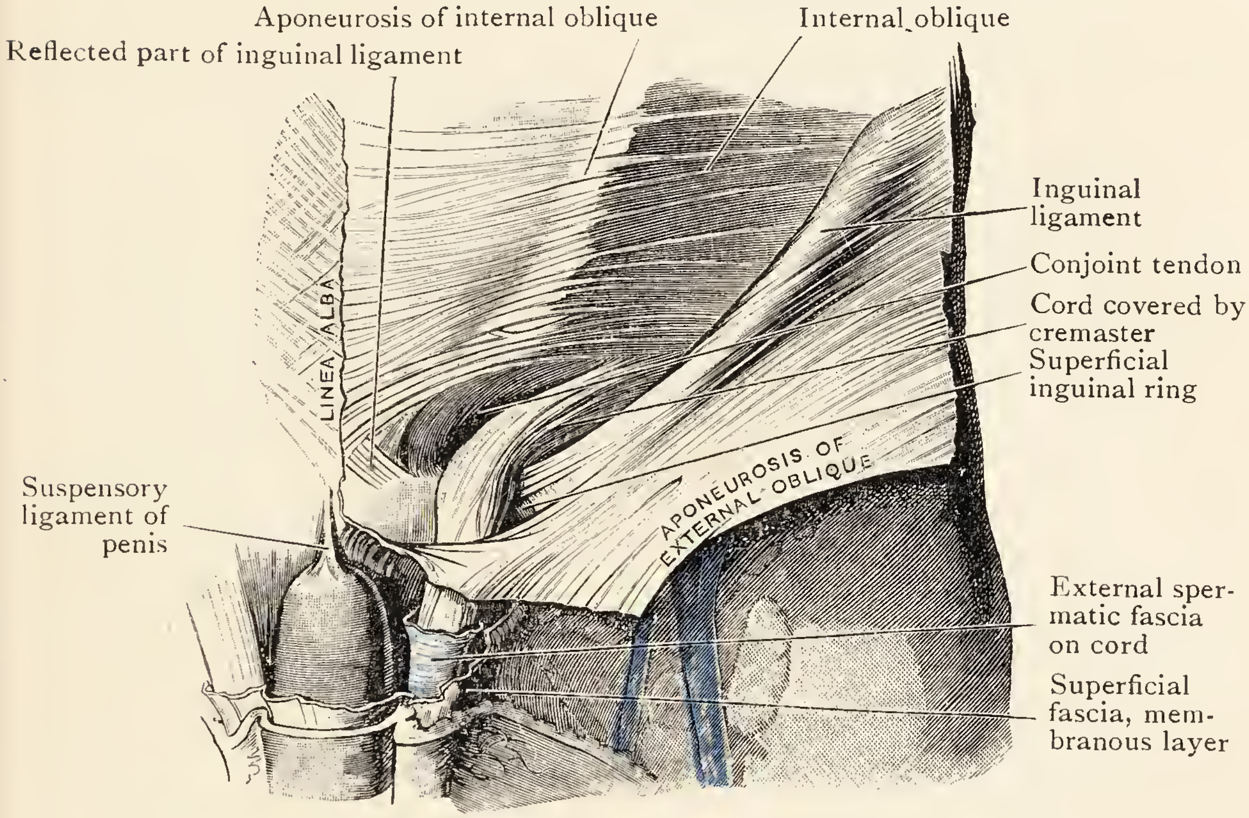


FIG. 96.—Dissection of Inguinal Region.
The aponeurosis of the external oblique is turned down.

Obliquus Internus Abdominis (Fig. 92).—The internal oblique muscle *arises*—(1) from the lateral two-thirds of the inguinal ligament; (2) from the anterior two-thirds of the iliac crest; and (3) from the lumbar fascia. The muscular fibres radiate from their origins, but their general direction is from below upwards and forwards. The *posterior fibres* ascend and are inserted, as fleshy fibres, into the cartilages of the lower three ribs.

The remainder of the muscle ends in a wide aponeurosis which spreads upwards and downwards as well as forwards—extending from the lower margin of the thorax to the pubis. By means of this aponeurosis, the main part of the muscle is inserted chiefly into the linea alba but also into the ninth, eighth and seventh costal cartilages and the xiphoid process superiorly and the pubic crest and pectineal line inferiorly.

Note that, while the external oblique covers part of the side and front of the chest, the internal oblique does not reach beyond the costal margin. The part of the rectus abdominis that reaches above the margin lies therefore directly on the costal cartilages, and the external oblique aponeurosis is the only one in front of that part.

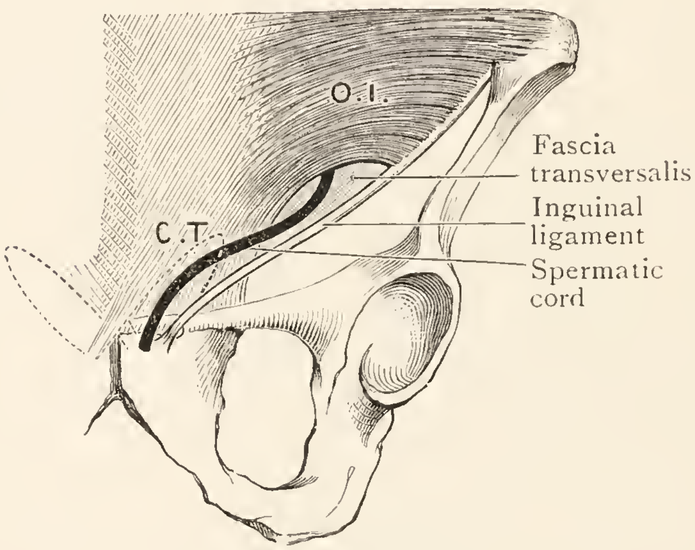


FIG. 97.—Diagram to illustrate the relation of lower border of Internal Oblique Muscle (O.I.) to Cord, Conjoint Tendon (C.T.) and Inguinal Canal.

The position of the superficial inguinal ring is indicated by a dotted outline.

The manner in which the aponeurosis reaches the median line requires special description. At the lateral margin of the rectus (*i.e.* opposite the linea semilunaris) it splits into two layers—a superficial and a deep. The *superficial layer* passes in front of the rectus, and fuses with the external oblique aponeurosis. The *deep layer* is carried medially behind the rectus, and fuses with the aponeurosis of the transverse muscle, which is deep to it (Fig. 114). But this arrangement does not hold good lower down than a level about midway between the umbilicus and the pubis. Below that level the aponeurosis does not split: it passes entirely in front of the rectus (Fig. 99).

The lowest part of the muscle requires still further attention, and special regard should be given to its relations to the spermatic cord or the round ligament. The lower border of the muscle is arched, and has a triple relation to the cord (or ligament). The fibres of the lowest part of the muscle, as they pass medially from the inguinal ligament, cross in front of the cord (or ligament) to gain a position above it. Then, becoming aponeurotic, they spread not only medially but also downwards behind it (Fig. 96), and are inserted into the pubic crest and the medial half inch (or more) of the pectineal line, behind the pubic attachments of the inguinal ligament.

Conjoint Tendon.—This is the name given to the lower part of the fused aponeuroses of the internal oblique and transverse muscles. It spreads medially in front of the rectus to the lower part of the linea alba and downwards to the pubic crest and the pectineal line; its lateral part, descending to the pectineal line, passes behind the spermatic cord or the round ligament, and is therefore a constituent of the posterior wall of the inguinal canal (p. 207). It is important to note the relation of the conjoint tendon to the superficial inguinal ring: it is immediately behind the ring, and gives strength to that otherwise weak spot in the abdominal wall.

Cremaster Muscle and Fascia.—As the lower border of the internal oblique muscle crosses the spermatic cord, some bundles of its fibres are dragged off by the cord in the form of fleshy loops which constitute the cremaster muscle.

The *cremaster muscle* supports the testis and spermatic cord, and is consequently peculiar to the male. It *arises* from the inguinal ligament in company with the lowest fibres of the internal oblique. The fleshy bundles descend over the lateral and anterior surfaces of the cord, and, looping upwards again on the back and medial side of the cord, are inserted by tendon into the pubic tubercle. The distance to which the loops descend varies. Some reach the testis; and the scrotum should now be opened up, on the right side, in order that the longest loops may be traced. The majority of the fibres, however, do not reach the scrotum—some going no farther than the superficial inguinal ring.

The cremasteric fleshy loops do not form a complete investment for the cord and testis, and the intervals between them are occupied by the areolar tissue which also envelops them. This tissue is known as the *cremaster fascia.*

The cremaster is supplied by the genital branch of the genito-femoral nerve and a branch from the inferior epigastric artery; and they enter its deep surface.

Nerves that pierce Obliquus Internus.—Note the points where these nerves pierce the muscle, and also their subsequent course.

The muscle is pierced by the *lateral cutaneous branch of the* *ilio-hypogastric* opposite the tubercle of the iliac crest and by the *lateral cutaneous branch of the subcostal nerve* a little farther forwards ; both nerves descend into the gluteal region. The *ilio-hypogastric nerve* pierces it an inch in front of the anterior superior spine (Fig. 92), and runs medially. The *ilio-inguinal nerve* pierces it lower down than the ilio-hypogastric and farther forward—near the inguinal ligament. It then enters the inguinal canal, and runs to the superficial ring to escape through it.

Dissection.—Reflexion of Internal Oblique. On the *right* side of the body the entire muscle may be reflected ; but on the *left* side leave the part which is still covered by the aponeurosis of the external oblique *in situ.*

Begin below by dividing the muscular fibres along the iliac crest. The depth to which the knife should be carried is indicated by the dense areolar tissue which lies between the internal oblique and the transversus. The ascending branch of the deep circumflex iliac artery also will serve as a guide. It emerges from the transversus near the anterior part of the iliac crest and runs upwards on its surface. On the right side, sever also the fibres that spring from the inguinal ligament ; but, on the left side, carry the knife horizontally from the anterior superior spine to the lateral margin of the rectus. Now, turn to the upper part of the muscle, and make an incision through it, along the lower margin of the thorax, from the lateral border of the rectus to the last rib. Lastly, carry the knife downwards from the tip of the last rib to the iliac crest.

The muscle freed in this manner can be reflected forwards towards the rectus ; but the dissectors must proceed with caution, because they have reached the plane of the main trunks of the nerves of the abdominal wall. These trunks pass medially between the internal oblique and transverse muscles, and, as the internal oblique is raised, they are apt to adhere to its deep surface and will be cut if proper care is not exercised.

In all probability the students will have difficulty in separating the lowest part of the internal oblique from the transversus abdominis, for the lower parts of the two muscles are always closely connected, and sometimes partially blended.

On the right side, make a longitudinal cut through the *cremaster muscle* and reflect it from the cord ; do that carefully in order to secure its nerve and artery. Then, clean the transversus abdominis muscle, and the vessels and nerves which lie on it.

Nerves of Anterior Wall of Abdomen.—The dissectors will find the following nerves running forwards over the transversus abdominis muscle :—

1. Five intercostal nerves 2. Subcostal nerve	Anterior primary rami of the lower six thoracic nerves.
3. Ilio-hypogastric nerve 4. Ilio-inguinal nerve	From the anterior primary ramus of first lumbar nerve.

The *lower five intercostal nerves* enter the abdominal wall at the costal margin by passing between the slips of origin of the transversus and insinuating themselves between that muscle and the internal oblique. They then run forwards to the lateral border of the rectus muscle, where they disappear by entering its sheath. In a subsequent dissection they will be seen sinking into the substance of the rectus, supplying it with twigs, and then turning forwards to pierce the front of the sheath. They end on the front of the abdomen as the *anterior cutaneous nerves* (p. 184). They supply offsets to the oblique and transverse muscles. Minute arteries accompany the nerves.

The *subcostal nerve* enters the wall by piercing the transversus near its origin from the lumbar fascia (p. 392), and takes the same course as an intercostal nerve ; it also supplies the oblique and transverse muscles, and, in addition, it gives a branch to the pyramidalis muscle.

The lateral cutaneous branches of those nerves have already been exposed and studied (p. 185).

The *ilio-hypogastric* and *ilio-inguinal* are the lowest two nerves of the series. Like the subcostal nerve, they pierce the posterior part of the transversus ; they then run onwards between the transversus and the internal oblique close to the iliac crest.

The ilio-hypogastric is the higher of the two. It gives off a *lateral cutaneous branch*, which pierces the two oblique muscles and then crosses the tubercle of the crest to reach the skin of the gluteal region. The main trunk of the nerve perforates the internal oblique about an inch in front of the anterior superior spine ; it then runs forwards and downwards, and terminates as the *anterior cutaneous branch*, which pierces the aponeurosis of the external oblique about an inch *above* the superficial inguinal ring and ramifies in the skin above the pubis.

The *ilio-inguinal nerve* gives off no lateral cutaneous branch. It gives branches to the internal oblique, and then pierces it a short distance above the lateral part of the inguinal ligament, below and medial to the ilio-hypogastric ; and, running medially between the internal oblique muscle and external oblique aponeurosis, it enters the inguinal canal, from which it escapes by passing *through* the superficial inguinal ring.

Transversus Abdominis.—The transversus is the deepest of the three muscular strata of the wall of the abdomen, and its deep surface is lined with a thin fibrous membrane called the *transversalis fascia*. The muscle has a threefold origin, viz.—from the pelvis, from the vertebral column, and

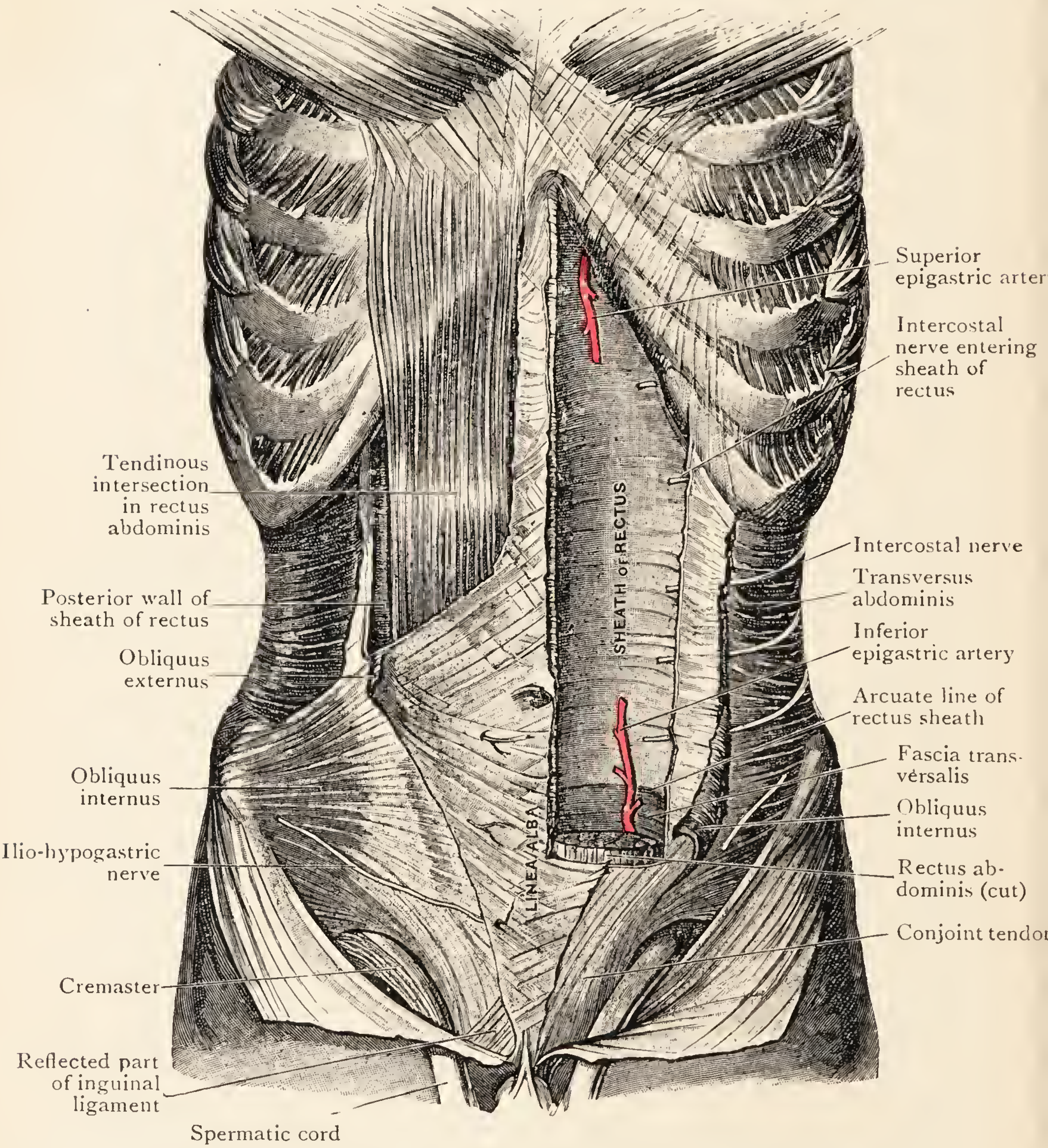


FIG. 98.—Deep dissection of Anterior Wall of Abdomen.

On the *left side* the external oblique and the internal oblique have for the most part been removed, the sheath of the rectus opened, and the greater part of that muscle removed. On the *right side* the external oblique, the upper part of the internal oblique, and the upper part of the anterior wall of the sheath of the rectus have been removed.

from the costal cartilages. By its *pelvic origin* it is attached to the lateral third of the inguinal ligament and to the anterior two-thirds of the inner lip of the iliac crest. By its *vertebral origin* it is attached, through the medium of the lumbar fascia, to the spines and transverse processes of the lumbar vertebræ (Fig. 114); indeed, the lumbar fascia constitutes the posterior aponeurosis of the muscle, and its connexions with the vertebral column will be studied later. By its *costal origin* it arises from the inner surfaces of the costal cartilages of the lower six ribs by a series of slips which interdigitate with the slips of origin of the diaphragm. (The diaphragm is the thin musculo-tendinous partition that separates the cavities of abdomen and thorax, and is also the chief muscle of respiration.)

Anteriorly, the fibres of the transversus abdominis muscle end in a strong aponeurosis which is inserted into the linea alba, the pubic crest, and the pectineal line. In passing medially to its insertion, the aponeurosis has two different relations to the rectus abdominis. Down to a level midway between the umbilicus and pubis, it passes *behind* the rectus, and blends with the back of the deep lamella of the internal oblique aponeurosis. Below that level, it passes in front of the rectus, fusing with the undivided, lower part of the internal oblique aponeurosis.

The fleshy fibres for the most part run in a horizontal direction towards the aponeurosis. The lower fibres, however, take a curved course downwards and medially, so that the muscle presents an arched lower margin.

The dissectors have already seen that the lowest portions of the aponeuroses of the transverse and internal oblique muscles blend to form the *conjoint tendon*. It is through the medium of the conjoint tendon that the transversus abdominis gains its insertion into the pubic crest and into the pectineal line. The transversus aponeurosis takes a larger share in the conjoint tendon than the internal oblique does, its attachment to the pectineal line being fully an inch long.

During the reflexion of the internal oblique, it was noted that its lower fleshy part is very closely connected with the transversus and may be partially blended with it.

Dissection.—Open the sheath of the rectus abdominis by a vertical incision along the middle of the muscle; raise the divided sheath and reflect it medially and laterally. The front of the sheath will be found to be blended in three or four places with tendinous intersections in the muscle, and the edge of the scalpel must be called into play ; otherwise, the sheath can be separated from the muscle with the handle of the scalpel. As the flaps are raised, preserve the anterior cutaneous nerves.

Contents of Sheath of Rectus.—The following structures are found within the sheath of the rectus :—

1. Rectus muscle.
2. Pyramidalis muscle.
3. Terminal parts of subcostal and lower five intercostal nerves.
4. Inferior epigastric artery, } with their veins and some of their
5. Superior epigastric artery, } branches.

Dissection.—Clean the *pyramidalis* muscle, which, if present, will be found in front of the lower part of the rectus ; detach it from the linea alba, and turn it downwards, securing its nerve of supply. Raise the lateral border of the rectus with the handle of the scalpel, and secure the terminal parts of the *intercostal* and *subcostal nerves* as they enter the sheath.

Follow the nerves into the muscle, and then cut them and the accompanying small arteries between the sheath and the muscle. Now, divide the rectus about the middle of its length and turn the parts upwards and downwards, noting that the posterior surface of the muscle is not attached to the sheath as the anterior surface is. Secure the *superior epigastric* and *inferior epigastric arteries*, which enter the sheath above and below respectively. Define the attachments of the two ends of the muscle.

The **pyramidalis** is a small triangular muscle—not always present—which springs from the front of the pubis and the ligaments of the symphysis, and is inserted into the linea alba. It lies on the front of the lower part of the rectus. It is a tensor of the linea alba; and it is supplied by a twig from the subcostal nerve which pierces the rectus to enter the deep surface of the muscle.

Rectus Abdominis.—The rectus abdominis is a long, broad band of muscular fibres which stretches between the pubis and the thorax, at the side of the linea alba. It *arises* from the pubic crest and the anterior pubic ligament. It widens as it ascends, but loses in thickness as it approaches the thorax. Its upper part passes on to the front of the chest to be inserted into the seventh, sixth and fifth costal cartilages along a horizontal line that extends from the xiphoid process to the end of the fifth rib.

The rectus muscle is broken up into segments by irregular *tendinous intersections*. They are usually three in number, and are placed—one at the level of the umbilicus, another near the xiphoid process, and a third midway between. A fourth intersection is sometimes found below the level of the umbilicus. The tendinous intersections are fused with the anterior wall of the sheath of the rectus ; but they have no attachment to the posterior wall.

Actions of Obliqui, Transversus and Rectus.—These muscles are very efficient protectors of the abdominal contents ; they contract and become firm and hard when blows or pressure threaten or impinge upon the abdominal wall. By their tonicity they maintain the intra-abdominal pressure by means of which the viscera are kept in position. They are muscles of expiration, because when they contract they press upon the abdominal viscera, tending to force them towards the thorax, so elevating the diaphragm and reducing the capacity of the thorax. They also play a part in defæcation, for their contraction increases the intra-abdominal pressure and so helps the rectum to evacuate its contents. The rectus, in addition, pulls the front of the thorax downwards towards the symphysis and is therefore a flexor of the vertebral column.

Nerve-Supply.—These muscles are all supplied by the lower five intercostal nerves and the subcostal nerve ; the oblique and transverse muscles receive additional twigs from the ilio-hypogastric and ilio-inguinal nerves.

Sheath of Rectus Abdominis.—The dissectors are now in a position to study the manner in which the sheath of the rectus is formed. An examination of the relations which the aponeuroses of the oblique and transverse muscles bear to the rectus will show that the sheath is incomplete, for, while the anterior wall of the sheath covers the muscle from end to end, the posterior wall is absent both above and below.

From the lower margin of the thorax to a level midway between the umbilicus and pubis it encloses the rectus on all sides. In that part of its extent the *anterior wall* is formed by the aponeurosis of the external oblique fused with the superficial layer of the aponeurosis of the internal oblique, and the *posterior wall* is formed by the deep layer of the aponeurosis of the internal oblique fused with the aponeurosis of the transversus abdominis (Fig. 114).

The *uppermost part* of the rectus rests directly on the costal cartilages, and the sheath is represented merely by the aponeurosis of the external oblique, which covers the muscle anteriorly. *Inferiorly*, the posterior wall of the sheath being absent, the rectus rests on the transversalis fascia. There the anterior wall is formed by all three aponeuroses (Fig. 99).

Turn to the posterior wall again. It extends from the costal margin to a level about midway between the umbilicus and the pubis. Examine its upper part. Note that the lateral part of this portion is not wholly aponeurotic, because the rectus overlies the seventh and eighth cartilages, and the fleshy part of the transversus that springs from them (and also from the ninth) is therefore behind the rectus. Now, examine the lower part and define the lower edge of the posterior wall of the sheath with the handle of the knife. The edge is arched, with the concavity downwards, and is called the *arcuate line* (linea semicircularis); the inferior epigastric artery enters the sheath by passing upwards in front of this

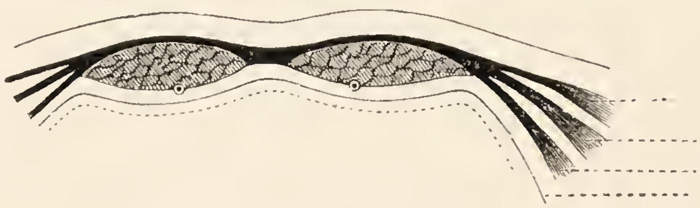


FIG. 99.—Transverse Section through Abdominal Wall a short distance above the Pubes. The dotted line represents the Peritoneum.

line. The arch may stand out quite distinctly owing to a slight thickening of the aponeurotic fibres. But this arched edge, though marked by a thickening, is seldom quite free, for a thin sheet is usually prolonged downwards from the transversus for some distance below it.

Lastly, turn to the lower part of the anterior wall of the sheath. Note that the fusion between the aponeuroses of the internal oblique and transversus is complete; but the aponeuroses of the two oblique muscles do not unite at once: their line of fusion is opposite a line drawn from the eighth costal cartilage to the linea alba a short distance above the pubis.

Linea Alba.—The linea alba can be studied to the best advantage at this stage. It is a dense, felted fibrous band which extends between the xiphoid process and the pubic symphysis. It is formed by the union and decussation of the fibres of the aponeuroses of the oblique and transverse muscles of the two sides. Above the umbilicus, it is half an inch wide or more, and its posterior surface is closely attached to the fascia transversalis. Below the umbilicus, it is narrow, and the two recti are therefore almost in contact with each other; and it is separated from the transversalis fascia by some fatty areolar tissue. The umbilicus is a little below its middle; but the foramen—of which it is the remains—is completely closed by scar tissue

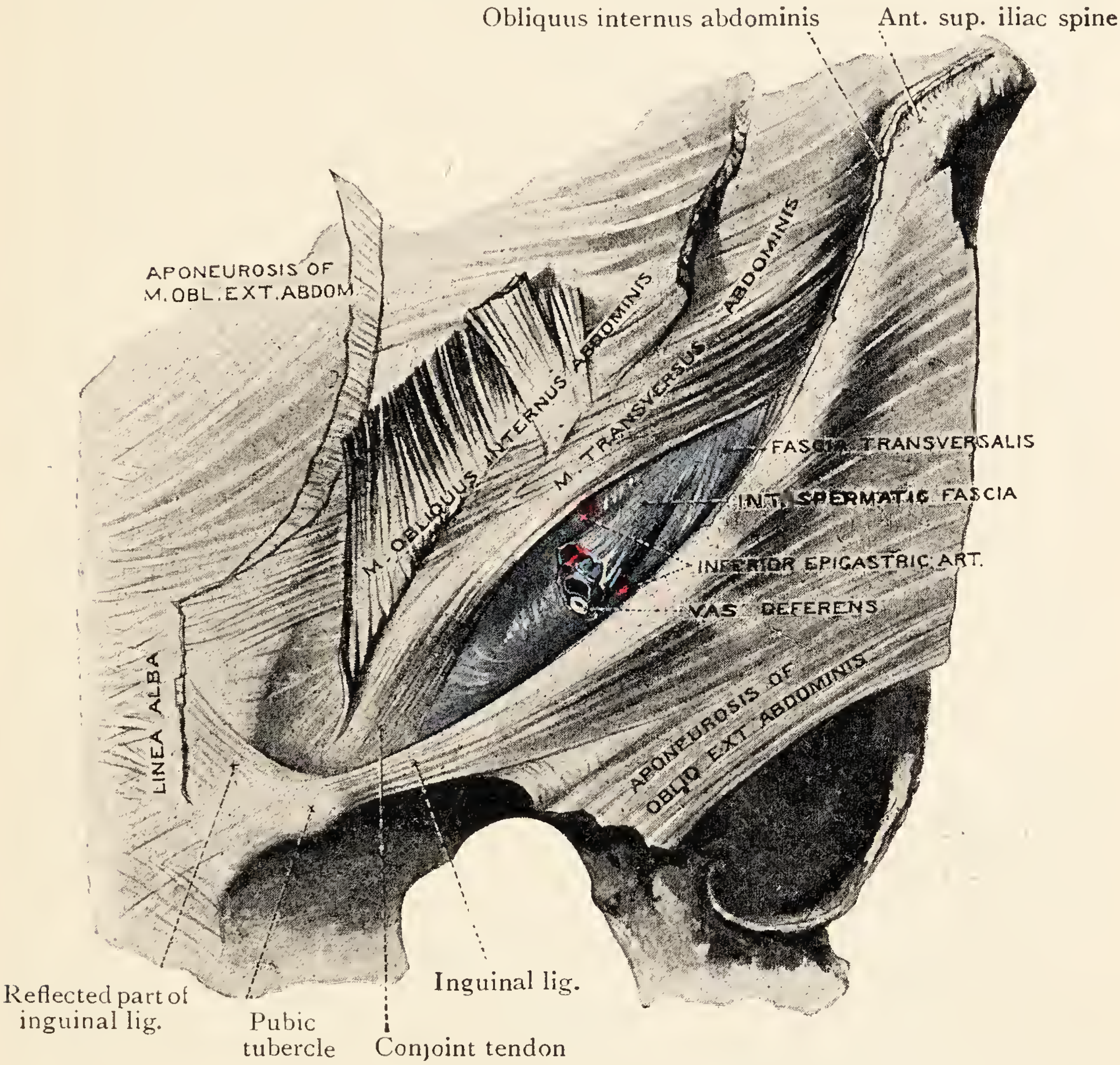


FIG. 100.—Deep dissection of Inguinal Region. The internal oblique has been reflected to show the whole length of the inguinal canal; and the cord, enclosed within the internal spermatic fascia, is seen cut across.

after birth; indeed, in the adult, the linea alba is stronger at the umbilicus than elsewhere.

Transversalis Fascia.—This is a thin layer of fascia spread out on the deep surface of the transversus abdominis muscle.

The fascia of one side is directly continuous, behind the linea alba, with the fascia of the opposite side, and is a part of an extensive fascial stratum which forms the innermost layer of all the walls of the abdomen. The deep or inner surface of the fascia is related to the parietal peritoneum, which is the smooth, glistening membrane that lines the inner surface of the abdominal walls. But it is not in immediate contact with the peritoneum. They are separated by a layer of areolar tissue, called the *extraperitoneal tissue*, in which there is a variable amount of fat.

Traced upwards, the transversalis fascia becomes thin, and, at the margin of the thorax, it is directly continuous with the fascia which covers the lower surface of the diaphragm. Traced backwards into the loin, it becomes loose and indefinite and blends with the loose fascia around the kidney in front of the lumbar fascia. Traced downwards, it has important connexions which the dissectors will presently proceed to display ; and they will note that in the inguinal region it plays an important part as a constituent of the posterior wall of the inguinal canal.

In the present state of the dissection (on the right side of the body), a small gap is seen between the lower border of the transverse muscle and the inguinal ligament. The membrane which fills up this interval is part of the *transversalis fascia.* At no part of the abdominal wall is the transversalis fascia stronger than here, and the accession of strength is obviously for the purpose of compensating for the deficiency in the transversus muscle, which, in that area, does not reach so low as the inguinal ligament.

Internal Spermatic Fascia.—The lower portion of the transversalis fascia has also an important relation to the spermatic cord in the male and to the round ligament of the uterus in the female. It is pierced by the cord or the round ligament, and the opening is called the *deep inguinal ring* ; but as yet no opening is visible, for the margins of the ring are prolonged over the cord or the ligament like the finger of a glove over a finger. To prove this take hold of the cord or the ligament and draw it downwards and medially. **In the female,** the ring is very small ; and its margins are prolonged for only a little distance over the ligament as a short sheath which soon blends with it. But **in the male,** the margins of the ring will be observed to be prolonged downwards over the cord in a funnel-shaped manner, so as to invest it with a tube of fascia. The investment, which is thus seen to come directly from the transversalis fascia, is called the *internal spermatic fascia.*

Dissection.—It is now the object of the dissectors to demonstrate the more important attachments of the transversalis fascia. Cut the right transverse muscle along the lateral part of the inguinal ligament and along the iliac crest ; raise it from the fascia and throw it upwards. It is not necessary to reflect the entire muscle. On the left side, reflect only the part of the muscle attached to the iliac crest.

Attachments of Lower Part of Transversalis Fascia.—When the fascia is cleaned with the handle of the scalpel, it will be seen to be attached *laterally* to the internal lip of the iliac crest. Along the line of that attachment (which is by no means firm) it becomes continuous with the *fascia iliaca*, which covers the iliacus and psoas muscles in the iliac fossa, and is also a portion of the fascial stratum that lines the walls of the abdomen.

In the inguinal region, the inferior connexions of the fascia transversalis are more complicated, and must be studied at three different places :—(1) Between the anterior superior iliac spine and the femoral artery, it will be seen to be attached to the inguinal ligament ; along that line also it becomes continuous with the fascia iliaca ; and in this situation, the deep circumflex iliac artery, having pierced the fascia iliaca a little lateral to the external iliac artery (Fig. 116), runs upwards and laterally in a fibrous canal situated at the junction of the fasciæ. (2) Opposite the femoral vessels, it is carried downwards into the thigh behind the inguinal ligament to form the anterior wall of the femoral sheath (Fig. 117). (3) Medial to the femoral vessels, it is attached to the pectineal line and the pubic crest behind the conjoint tendon, with which it is partially fused.

Deep Inguinal Ring.—It has been noted that the transversalis fascia is pierced by the spermatic cord or by the round ligament, and that the opening is called the *deep inguinal ring.* The margin of the ring is prolonged downwards, and, in the female, soon blends with the ligament ; but, in the male, it extends to the scrotum and invests the whole length of the cord with the tubular sheath called the *internal spermatic fascia.* It follows, therefore, that the opening can be defined, from the front, only by dissection, viz.—dividing the fascia around the cord or the round ligament near the ring and pushing it upwards with the handle of the knife. The ring thus defined is less than half an inch above the mid-inguinal point. Through the opening the dissectors will see the extraperitoneal fat on which the transversalis fascia rests, and, at the medial margin of the opening, the inferior epigastric artery is visible through the fascia, pursuing its oblique course upwards and medially. If the handle of the knife is now introduced into the ring and carried laterally between the fascia and extraperitoneal fat, the attachments of the fascia to the inguinal ligament and to the iliac crest can be demonstrated.

Inguinal Canal.—It has been shown that the spermatic cord (or the round ligament) pierces the abdominal wall above the inguinal ligament. The passage which is formed for its transmission receives the name of the *inguinal canal.* The canal is a source of weakness to the abdominal wall ; in both sexes, every form of inguinal hernia passes through some part of it, and the dissectors will understand, therefore, how necessary it is that they should examine its position and its walls carefully from all points of view.

In the female, the inguinal canal transmits the round ligament of the uterus, and is much narrower than in the male ; but it has the same position and boundaries, and the following paragraphs apply therefore to both sexes.

The inguinal canal is a narrow channel about an inch and a half in length. It begins at the deep inguinal ring and ends at the superficial inguinal ring. Its direction is therefore medialwards with a slight inclination downwards and forwards. So much for its length and direction : its floor, its anterior wall, its posterior wall and its roof have now to be examined.

The *floor* of the lateral part of the canal is the upper, grooved surface of the inguinal ligament. Medially, however, the floor becomes broader and more definite ; there, it is formed by the inguinal ligament and its pectineal expansion. At that point, as the dissectors have previously noted, the cord or the round ligament rests directly on the abdominal surface of the pectineal part of the inguinal ligament.

The parts which enter into the formation of the *anterior wall* are :—(1) the aponeurosis of the external oblique throughout the entire extent of the canal ; and (2) the lowest fleshy fibres of the internal oblique in the lateral half of the canal. These statements can be readily confirmed if the structures are restored to their original positions. The parts which compose the *posterior wall* are still *in situ*. Named in order from behind forwards, they are :—(1) the transversalis fascia in the entire length of the canal; (2) the conjoint tendon in the medial half; and (3) the reflected part of the inguinal ligament (when it is present) in the medial fourth (Fig. 101).

But, it may be asked, does the fleshy part of the transversus abdominis take no part in the formation of the inguinal canal? The students can readily satisfy themselves on that point. They will notice that the lower border of the transversus muscle does not reach so far down as the lower border of the internal oblique does; that, in fact, it stops short a little above the deep inguinal ring. The canal is closed *superiorly* by the lower border of the internal oblique alone, which arches from the anterior wall to the posterior wall above the round ligament or the cord, forming the *roof* of the canal (p. 194).

Inguinal Triangle.—There is still another point to be noted, viz., the relation which the inferior epigastric artery bears to the posterior wall of the canal. That vessel can be felt (and, indeed, in most bodies, seen) extending obliquely upwards and medially to the lateral border of the rectus; it is close to the medial margin of the deep ring, in the extraperitoneal tissue, and therefore immediately behind the posterior wall of the canal. The triangular area thus mapped out by the inferior epigastric artery, the inguinal ligament, and the lateral border of the rectus receives the name of the *inguinal triangle*. The lower part of the floor of the triangle is therefore the posterior wall of the inguinal canal.

Summary of Inguinal Rings.—Before the dissectors leave this region they should review the leading anatomical features of the inguinal rings.

The **deep inguinal ring** is an opening in the transversalis fascia less than half an inch above the mid-inguinal point and immediately lateral to the inferior epigastric vessels; and the internal spermatic fascia is prolonged from its margins. It is not quite wide enough to admit the tip of the little finger in the male, and it is narrower in the female, for, *in the female*, it transmits only the round ligament of the uterus with its vessels and nerve. *In the male*, it transmits:—(1) the spermatic cord; (2) the cremasteric vessels and the genital branch of the genito-femoral nerve for the supply of the cremaster muscle; and (3) a fibrous thread called the vestige of the processus vaginalis—the thread being the remains of a tube of peritoneum that preceded the testis and cord in their descent through the canal (see p. 215).

The **superficial inguinal ring** is an aperture in the external oblique aponeurosis immediately above the pubic tubercle and the medial end of the inguinal ligament. It is more or less triangular in outline, with its base on the pubic crest and its apex pointing sidewards and upwards. The sides of the triangle are called crura—a superior crus and an inferior. They are kept from spreading apart by intercrural fibres; the external spermatic fascia springs from the margins of the opening and from these fibres. The medial part of the inferior crus is the medial part of the inguinal ligament and the spermatic cord or the round ligament rests on it.

In the male, it transmits:—(1) all the structures transmitted by the deep ring; (2) the internal spermatic fascia and the cremaster muscle and fascia; and (3) the ilio-inguinal nerve. It is barely wide enough to admit a finger-tip.

In the female, it is much narrower; and it transmits the round ligament with its nerve and vessels, and the ilio-inguinal nerve.

ARTERIES OF ANTERIOR WALL OF ABDOMEN.—The chief arteries in the anterior abdominal wall are:—

1. Deep circumflex iliac.
2. Inferior epigastric.
3. Superior epigastric.
4. Musculo-phrenic.
5. Posterior intercostal, subcostal, and lumbar.

The *posterior intercostal arteries* of the lower two spaces and the subcostal artery are prolonged forwards between the internal oblique and the transversus abdominis in company with the corresponding nerves.

Owing to the smallness of the interval between the iliac crest and the lower ribs, the only branches of *lumbar arteries* found are insignificant twigs between the posterior parts of the internal oblique and transversus.

Inferior Epigastric Artery.—This artery arises from the external iliac artery immediately above the inguinal ligament. It is a vessel of some size, and at present it is seen shining through the transversalis fascia and forming the lateral boundary of the inguinal triangle. Divide the transversalis fascia along its course; note the two veins which accompany the artery, and then study its course and relations.

Course and Relations.—At first the artery runs medially for a short distance, between the inguinal ligament and the deep inguinal ring, and then, changing its direction, it is carried upwards and medially along the medial margin of the ring towards the lateral border of the rectus abdominis, where it pierces the transversalis fascia. It continues upwards behind the rectus and, passing in front of the arcuate line, it enters the sheath of the rectus, and soon ends in branches which sink into the rectus and send twigs through it to the skin.

In the lower parts of its course the artery is embedded in the extraperitoneal fat between the peritoneum and the transversalis fascia; then, having pierced that fascia, it is situated between the fascia and the rectus; finally, having passed in front of the arcuate line, it lies between the rectus and the posterior wall of its sheath. In addition to the relations mentioned, it has others of equal importance, viz.:—(1) as it runs upwards it lies close to the medial margin of the deep inguinal ring; (2) as the spermatic cord or the round ligament of the uterus enters the inguinal canal it lies in front of the artery, separated from it only by the transversalis fascia; (3) as the vas deferens (or the round ligament) is traced from the inguinal canal into the abdominal cavity it hooks round the lateral side of the artery.

Branches.—Besides *muscular* branches to the rectus and *cutaneous* branches which pierce the rectus and the aponeuroses to reach the skin, the inferior epigastric artery gives off two named branches—the *pubic* and the *artery to the cremaster.*

The *artery to the cremaster* is a slender vessel which arises near the medial margin of the deep inguinal ring, and passes through the ring into the inguinal canal to supply the cremaster muscle and anastomose with the testicular artery. In the female, it is named the *artery to the round ligament of the uterus*, for it supplies that ligament.

The *pubic branch*, also slender, runs downwards to ramify on the back of the pubis, and one of its branches anastomoses with the pubic branch of the obturator artery. The importance of the pubic branch arises from the fact that this anastomosis sometimes becomes so large that it takes the place of the obturator artery and may be in danger in an operation to relieve a femoral hernia.

Deep Circumflex Iliac Artery.—This artery springs from the external iliac artery about the same level as the inferior epigastric, and runs laterally, behind the inguinal ligament, to the anterior superior iliac spine; from that point onwards it takes the iliac crest as its guide and runs along it for half its length. At first it is placed in the extra-peritoneal fat, but soon pierces the fascia iliaca and then runs to the iliac crest in a fibrous canal at the junction of the fascia iliaca and transversalis fascia; at a variable point beyond the anterior superior iliac spine, it pierces the transverse muscle; and its terminal branches ramify between the transverse and internal oblique muscles.

Before it reaches the anterior superior iliac spine it gives off its *ascending branch*, which pierces the transversus and ascends between that muscle and the internal oblique. Although this vessel waited long to attain the dignity of a name, it is a very constant branch.

Superior Epigastric and Musculo-Phrenic Arteries.—These arteries are the terminal branches of the internal mammary artery.

The *superior epigastric* will be found behind the rectus muscle, in the upper part of its sheath. From its origin behind the sixth intercostal space near the sternum it descends behind the seventh costal cartilage, passes between the sternal and costal origins of the diaphragm and pierces the upper end of the posterior wall of the sheath of the rectus. Having entered the sheath, it soon ends in branches which sink into the rectus and supply it and the overlying skin; but one long slender branch is named the *hepatic branch* because it ends in the liver. This branch descends to the umbilicus and reaches the liver by running along a slender band, called the *round ligament of the liver*, which extends from the umbilicus to the liver.

Dissection.—**To expose the musculo-phrenic artery, detach the transversus abdominis from the rib-cartilages on each side. The artery will be found, if the injection has been good, at the eighth costal cartilage. Follow it along the costal margin.**

The *musculo-phrenic* artery enters the abdomen between the slips of the diaphragm from the seventh and eighth cartilages, and runs along the costal origin of the diaphragm as far as the last intercostal space. It gives branches to the diaphragm and to the anterior wall of the abdomen, and sends two anterior intercostal arteries into each of the seventh, eighth, and ninth intercostal spaces.

Dissection.—**Divide the transversus vertically between the ribs and the iliac crest, and throw the anterior part towards the median plane, carefully detaching the transversalis fascia from its deep surface.**

Examine the share which the transversus takes in the formation of the upper part of the sheath of the rectus on both sides, and in the formation of the conjoint tendon of the right side.

In the area lateral to the sheath of the rectus abdominis the only structures which now separate the dissectors from the peritoneal cavity are the transversalis fascia, the extraperitoneal fat, and the peritoneum. Do not attempt to reflect the transversalis fascia as a whole, but make an incision through it near the margin of the ribs or near the iliac crest to display the extraperitoneal fat ; scrape away some of the fat to expose the peritoneum ; finally, make a small incision through the peritoneum and insert the finger to demonstrate that the space enclosed by the peritoneum—the *peritoneal cavity*—has been reached.

The dissectors of the female *abdomen will now pass to the Dissection of the Loin on p.* 229.

Male External Genital Organs

The dissectors of the male abdomen should now examine the genital organs that lie outside the pelvis. They are the penis, the scrotum, a pair of testes (each with an epididymis) and a pair of spermatic cords.

They should begin with the scrotum ; and after they have gained a general idea of its constituent parts they should proceed to dissect it.

Scrotum.—The scrotum is a pendulous purse-like arrangement of skin and fasciæ for the lodgment of the testes.

The *skin* is dark in colour, rugose and studded sparsely with hairs ; and it is traversed, along the middle line, by a *median raphe* or ridge which indicates its bilateral origin.

The *superficial fascia* possesses certain characters peculiar to itself. It has a ruddy colour, and is totally devoid of fat. The ruddy tint is due to the presence of involuntary muscular fibres which take the place of the fat, and constitute what is called the *dartos muscle*. The rugosity of the scrotal skin is maintained by the tonic contraction of the dartos muscle, whose superficial fibres are attached to the skin. Further, the dartos muscle sends a septum into the interior of the scrotum to divide it into two chambers—one for each testis. The septum is, however, incomplete superiorly.

But these two tunics are not the only layers in the scrotal wall. Three of the constituents of the abdominal wall have been seen to contribute an investment to the spermatic cord ; and they are continued down into the scrotum, thus providing for each testis three additional coverings which are called the *coats of the testis*. When the dissection has reached the stage at which the skin and superficial fascia are removed, further dissection will disclose each of the three coats in turn :—

1. The external spermatic fascia, from the external oblique aponeurosis.
2. The cremaster muscle and fascia—the muscular element of which is derived from the internal oblique.
3. The internal spermatic fascia, from the fascia transversalis.

The external spermatic fascia will be found, however, to be little more than a layer of areolar tissue under the dartos ; and, though the skin and the superficial fascia are common to both chambers, it will be noted that those three additional layers are confined to the chamber of the corresponding side, owing to the septum sent into the scrotum by the superficial fascia and the dartos muscle.

Nor is this all. There is still another layer, called the *tunica vaginalis testis*, which, as we shall see, is developmentally a portion of the peritoneum. It is therefore a serous membrane, and, like the other serous membranes—peritoneum, pericardium and pleura—it has a parietal layer and a visceral layer separated by a capillary interval that contains a film of lymph to keep the surfaces of the layers moist. The parietal layer lines the wall of the scrotal chamber, and is closely adherent to the internal spermatic fascia ; at the back wall of the scrotum, it is reflected forwards to become continuous with the visceral layer. The visceral layer clothes first the epididymis (which lies on the back of the testis) and then the testis itself.

In cases of old inguinal herniæ where the coats of the testis and spermatic cord have become thickened, they can be separated and displayed to advantage, but in an ordinary dissection, although the dartos and the tunica vaginalis are readily identified, the student will find that the external spermatic fascia, the cremaster, and the internal spermatic fascia are less easily defined, and a satisfactory demonstration of them is difficult. Nevertheless, the attempt should be made; and if the steps to be described are followed an

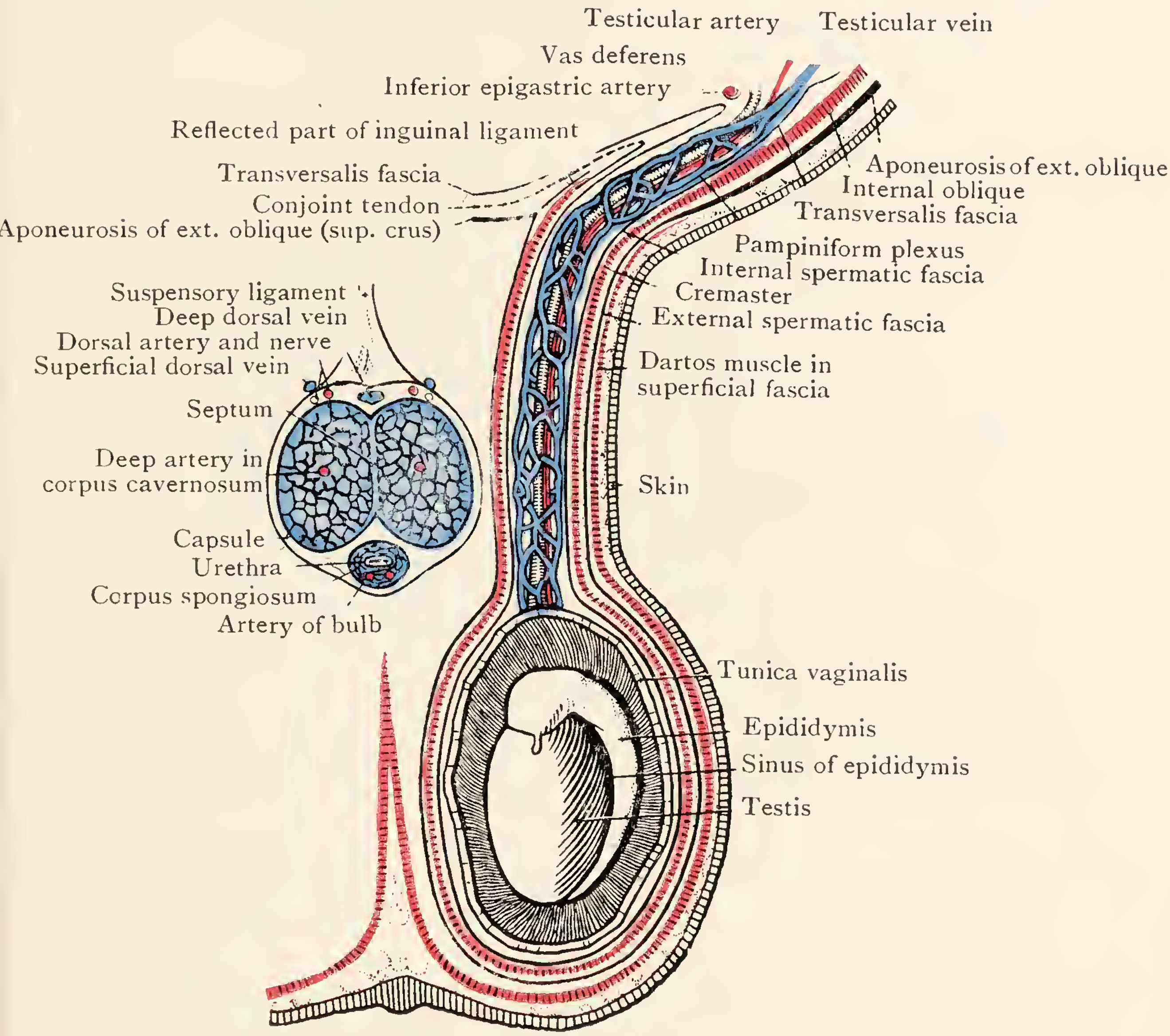


FIG. 101.—Diagram of Coronal Section through Penis and Left Part of Scrotum.

excellent demonstration of the constituent parts of the spermatic cord will be obtained.

Dissection.—On the *right* side, make an incision through the skin of the antero-lateral aspect of the scrotum, from the region of the superficial inguinal ring to the lower end of the scrotum. Reflect the medial part of the divided skin towards the median plane. Remember that the superficial fibres of the dartos are attached to the skin, and therefore keep the edge of the scalpel playing against the skin as the reflexion proceeds.

When the skin is reflected, the dartos tissue is obvious owing to its yellowish-pink colour. Reflect it in the same way as the skin. As the median plane is reached a layer of the dartos muscle will be found extending upwards as a septum between the testes. The layer of rather loose areolar tissue exposed by the reflexion of the dartos is the external spermatic fascia. With the handle of the scalpel and the fingers separate it from the deep surface of the dartos. Begin the separation at the lower end of the scrotum and proceed upwards to the superficial inguinal ring.

When the separation of the external spermatic fascia from the dartos is completed, the testis and the spermatic cord and their coats are free, and they can be lifted from the scrotum Examine now the extraperitoneal fatty tissue behind the deep inguinal ring of the right side ; separate the fat gently from the peritoneum that overlies the ring (and often bulges slightly into it), and look for a fibrous thread that passes into the inguinal canal from that portion of the peritoneum. This thread is the vestige of the processus vaginalis.

Vestige of Processus Vaginalis.—This is a fibrous filament which springs from the peritoneum that overlies the deep inguinal ring. It is the remains of a tube of peritoneum, called the *processus vaginalis*, which connected the tunica vaginalis testis of the fœtus with the peritoneum. It passes into the inguinal canal, and can be traced as far as the testis in some bodies, but more commonly it extends into the canal for only a short distance ; indeed, it is often absent.

Descent of Testis.—To obtain a proper conception of this vestige, it is necessary that the students should understand that neither the testis nor the tunica vaginalis is developed in the scrotum. In the early months of intra-uterine life the rudimentary scrotum has no cavity, and the testis is in the abdomen. It is developed high up on the posterior wall of the abdomen ; but in the third month, owing to the growth changes which have occurred, it is found lying in the iliac fossa. This is the first stage of its *descent*. It now projects forwards into the peritoneal cavity, anchored to the posterior abdominal wall by a fold of the peritoneal membrane known as the *mesorchium* ; and its blood-vessels reach it by running to it between the two layers of that fold. (See the general account of the peritoneum and "mesenteries," p. 249). The testis remains for a relatively long period in the iliac fossa, and at the seventh month of intra-uterine life it is found lying immediately above the inguinal ligament (Fig. 102).

Meanwhile a diverticulum of peritoneum, called the *processus vaginalis*, is projected through the inguinal portion of the abdominal wall into the scrotum; by its passage, it produces the inguinal canal and prolongs the cavity of the peritoneum into the scrotum. During the latter part of the seventh

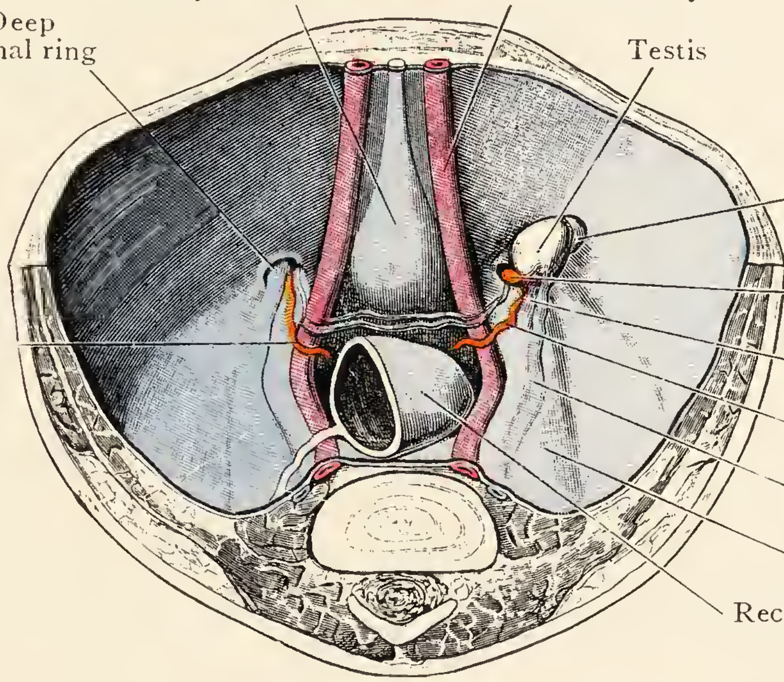


FIG. 102.—Pelvis and Lower Part of Abdominal Cavity in a Fœtus of about the seventh month, seen from above. (A. F. Dixon)

On the left side, which represents a slightly more advanced condition than the right, the testis has entered the inguinal canal; on the right side the testis is still within the abdominal cavity.

month, the testis, with its mesorchium, descends along the posterior wall of this diverticulum (Fig. 103 c); during the eighth month it reaches the superficial inguinal ring, and during the ninth month it comes to rest near the lower end of the scrotum, where it bulges forwards into the lower part of the processus vaginalis, invaginating the posterior wall of the processus (Fig. 103 d).

The orifice of communication between the cavity of the processus vaginalis and the peritoneal cavity is closed usually before birth; the cavity of the part of the processus that extends from the deep ring to the scrotum is obliterated usually during the first month after birth, and its walls become a fibrous thread—*the vestige of the processus vaginalis*.

The part of the processus that reached the scrotum persists as the *tunica vaginalis testis*. Its cavity is now entirely separated from the cavity of the peritoneum, but its wall is still connected with the peritoneum, for a longer or shorter time, by the vestige of the processus. Usually, however, the vestige undergoes atrophy from below upwards, and frequently, as already indicated, it entirely disappears.

The cause of the descent of the processus vaginalis and

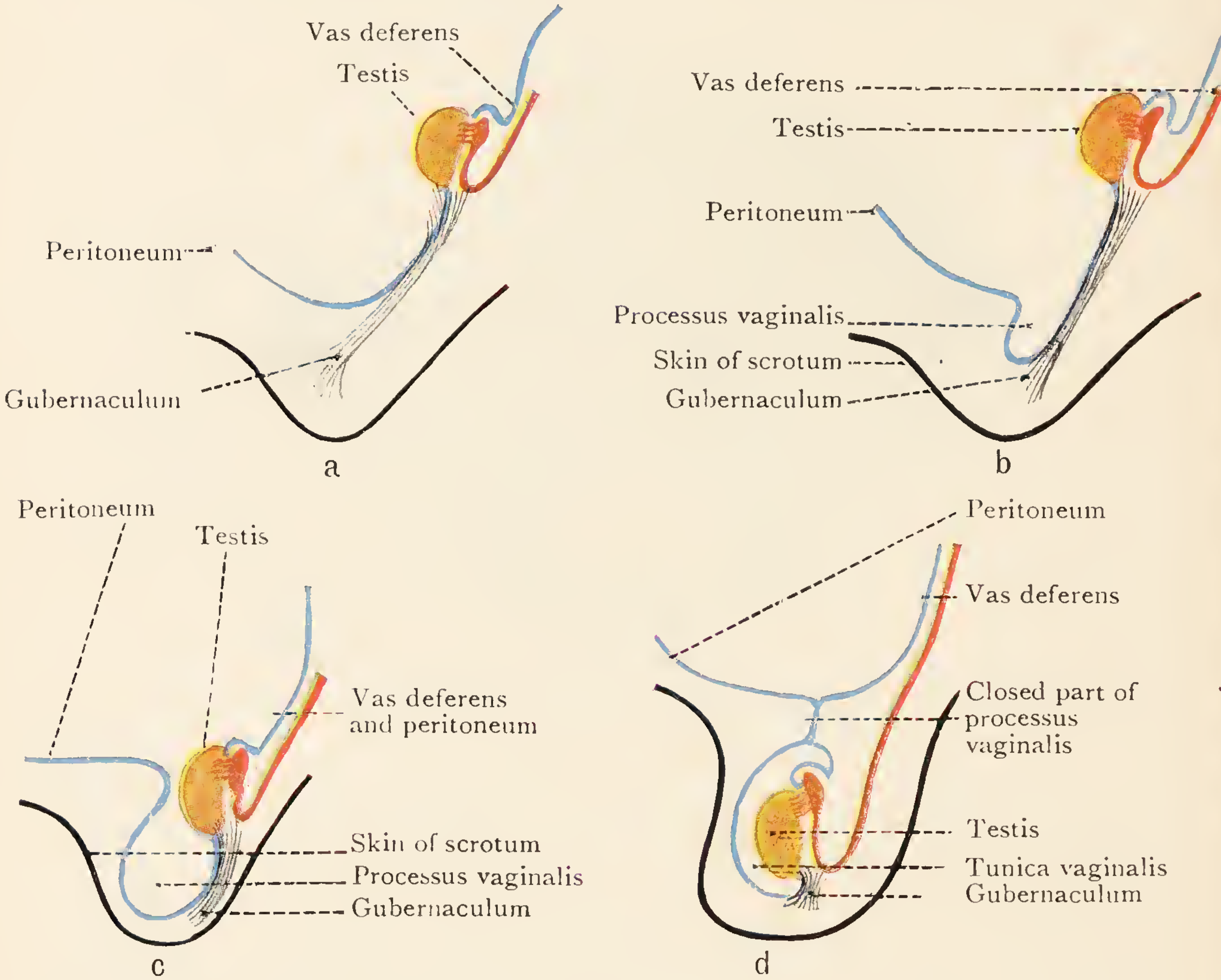


FIG. 103.—Diagrams illustrating Descent of Testis and Derivation of Tunica Vaginalis from the peritoneal lining of abdomen.

the testis is still a subject of dispute. It has been suggested that it is due—(1) to traction from below produced by a musculo-fibrous cord, called the *gubernaculum of the testis* (John Hunter), which develops in the inguinal part of the abdominal wall and is attached inferiorly to the tissues of the scrotum, and superiorly to the testis and the adjacent peritoneum; (2) to differential growth in adjacent parts; (3) to the action of intra-abdominal pressure, tending to displace the testis downwards. Whatever may be the rôle of the other factors mentioned, there is no doubt that the gubernaculum plays an essential part in the formation of the processus vaginalis and in guiding the testis in its descent to the scrotum.

There are many interesting points about the position of the testis and the phenomenon of its descent, periodical or permanent, in different animals; and students should distinguish carefully between the mechanism present and its physiological reason. This is supposed to be connected with the inhibitory effect on the functioning of the testis of either the intra-abdominal pressure or the intra-abdominal temperature, which is higher than the temperature of the scrotum.

It should be noted also that the descent of the testis may be arrested in the fœtus at any stage, with resulting various degrees of *undescended testis* or *cryptorchism* (from the Greek: *kryptos* = hidden; *orchis* = testis).

Spermatic Cord.—This is a long, rounded bundle that extends from the deep inguinal ring to the scrotum, where it terminates behind the upper end of the testis. It is formed by the association together of certain blood-vessels, nerves, and lymph-vessels, along with the vas deferens—all of which are proceeding to or from the testis. The structures come together at the deep inguinal ring, and that may be taken as the point at which the cord begins. It is encased in the three tubular coats derived from the abdominal wall during the descent of the testis, namely—the internal spermatic fascia, the cremaster muscle and fascia and the external spermatic fascia.

The cord has already been traced in its course through the inguinal canal, and has been observed to issue from the canal through the superficial inguinal ring. It is now seen as it lies within the scrotum suspending the testis.

The constituent parts of the spermatic cord are the following:—

1. Vas deferens.
2. Blood-vessels $\begin{cases} \text{Arteries} \begin{cases} \text{Artery of vas deferens.} \\ \text{Testicular.} \end{cases} \\ \text{Veins—Pampiniform plexus.} \end{cases}$
3. Lymph-vessels.
4. Nerves—Sympathetic filaments.

The constituent parts are all held together by loose areolar tissue and by the three coats.

The vas deferens is in the posterior part of the cord and is accompanied by its artery, which may be partly embedded in it. The testicular artery is in front of the vas. The veins form a dense network called the pampiniform plexus, which is by far the bulkiest of the constituents; it surrounds the vas and the arteries, but is bulkiest in front of them. The sympathetic nerve-filaments form plexuses around the arteries. And the lymph-vessels thread their way through the network of veins.

Dissection.—The dissection of the coats and constituents of the extra-abdominal part of the spermatic cord is done best under water. Divide the right cord at the superficial inguinal ring; place the cord and the testis with their coats in a cork-lined tray; fasten the testis and the cord to the cork with pins, and fill the tray with water. Divide the external spermatic fascia longitudinally and turn it aside; next, make a longitudinal incision through the cremaster muscle and fascia and turn it downwards over the testis. Deal in a similar manner with the internal spermatic fascia, and, as the testis is approached, be careful not to injure the layer of the tunica vaginalis that lines the deep surface of the internal spermatic fascia. Lastly, dissect out the parts of the cord.

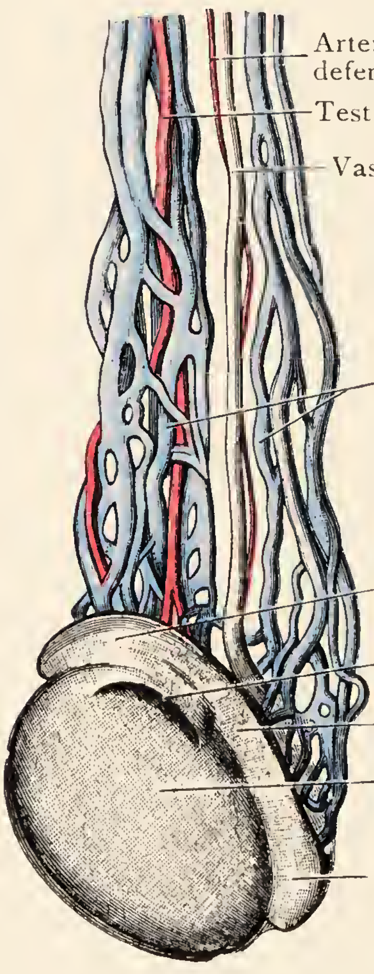


FIG. 104.—Dissection of Left Spermatic Cord to show its constituent parts. (From Waldeyer, modified)

The **vas deferens** is a portion of the channel through which the spermatozoa pass from the testis to the urethra. It is, therefore, the most important constituent of the cord. It can always be distinguished, both in the living and the dead body, by the hard, firm, cord-like sensation which it gives when the spermatic cord is held between finger and thumb. It begins at the lower end of the epididymis, and is at first sinuous and even convoluted (Fig. 107). It ascends, behind the testis, along the medial side of the epididymis, to join the other constituents of the spermatic cord, in which it first ascends to the superficial inguinal ring and then traverses the inguinal canal. At the deep ring, it leaves the plexus of veins and the testicular artery, and, accompanied only by its own artery, it hooks round the inferior epigastric artery and passes into the pelvis. Its pelvic course is described on p. 454.

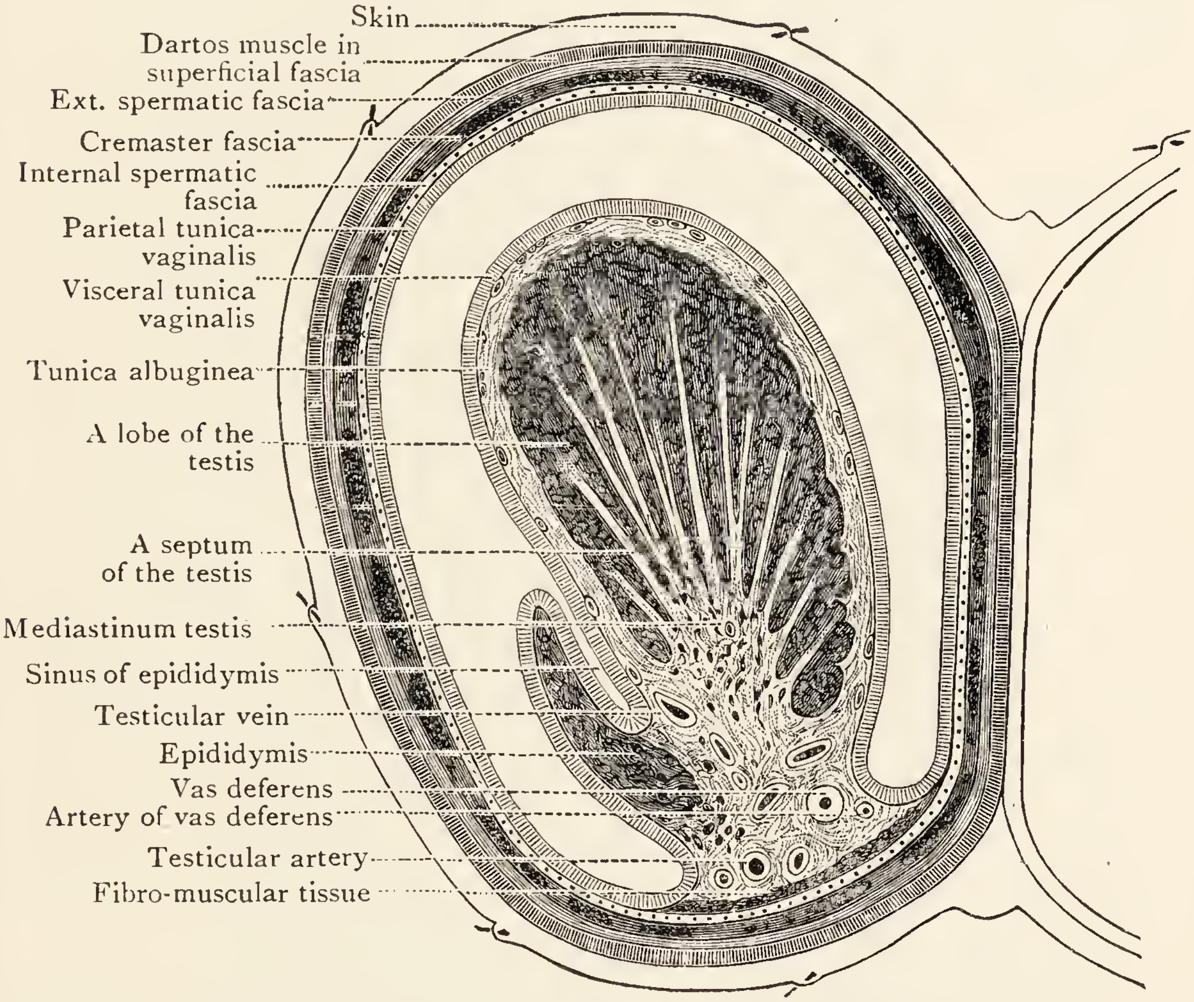


FIG. 105.—Transverse Section through left half of Scrotum and Left Testis, seen from above. The sac of the tunica vaginalis is represented in a distended condition.

The *artery of the vas deferens* is a slender branch of the inferior vesical artery. It passes along the vas to the testis.

The *testicular artery* arises from the front of the aorta; it enters the cord at the deep inguinal ring, proceeds to the testis, and divides into several small branches that sink into the testis through its posterior border.

Numerous veins issue from the testis at its posterior border, and as they pass upwards they form a bulky plexus termed the *pampiniform plexus*—because of their resemblance to twisted *pampini* = the tendrils of a vine (Fig. 104). The *testicular vein* issues from the plexus at or near the deep inguinal ring, and ascends over the posterior wall of the abdomen. The right vein ends in the inferior vena cava;

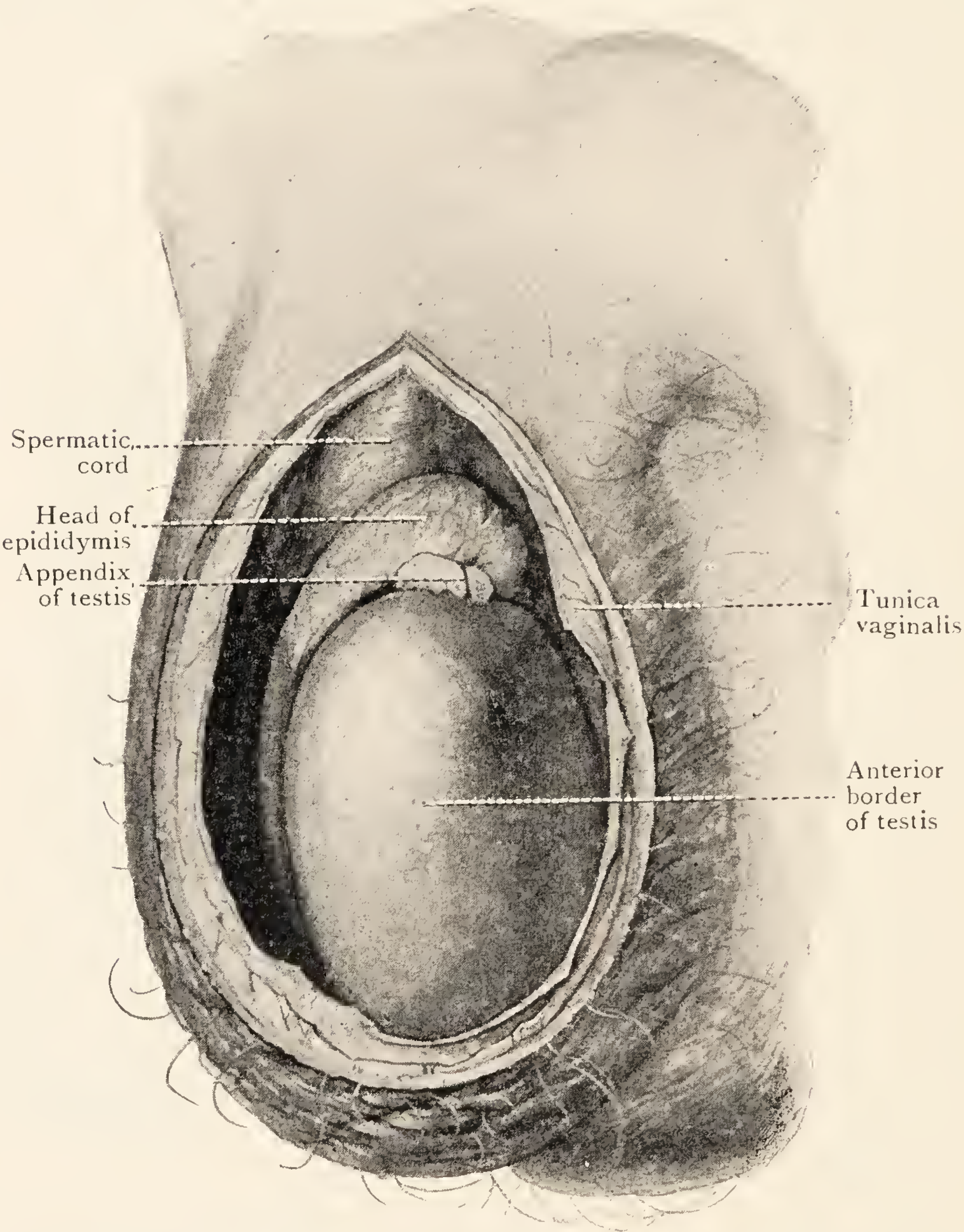


FIG. 106.—Right Testis and Epididymis within Tunica Vaginalis exposed by removal of anterior wall of scrotum. (A. F. Dixon)

the left joins the left renal vein. In the lower part of the abdomen, the vein is frequently double.

The *sympathetic filaments* form a plexus around the testicular artery. They come from the renal and aortic plexuses.

The *testicular lymph-vessels* enter the abdomen through the inguinal canal with the other constituents of the spermatic cord, and run upwards on the posterior abdominal wall, where they spread out to join the aortic lymph-glands from the bifurcation of the aorta upwards as high as the level of the renal veins (Fig. 194, p. 386).

Dissection.—The tunica vaginalis has still to be examined. To demonstrate its extent, make a small incision through its anterior wall ; introduce a blow-pipe through the incision and distend the sac. Note that the cavity passes upwards on to the front of the lower part of the spermatic cord (Fig. 106). Now, with the scissors, open the sac by extending the incision to the upper and lower limits of the cavity.

Tunica Vaginalis Testis.—This is an invaginated serous sac and has therefore an outer or parietal layer and an inner or visceral layer, which are continuous with each other (see p. 249). The *parietal* layer lines the inner surface of the internal spermatic fascia ; its outer surface is rough and flocculent ; its inner surface and the opposed surface of the visceral layer are smooth and glistening. The *visceral* layer covers the front and sides of the testis and epididymis, and it is continuous with the parietal layer at the back. In ordinary circumstances the parietal and visceral layers are separated only by a potential cavity containing a thin layer of fluid which diminishes friction when the layers move over each other ; but in some abnormal circumstances the fluid increases in quantity, the two layers of the sac are forced apart, and the condition called " hydrocele " is produced.

On the lateral side the visceral layer is tucked in between the testis and the epididymis to line a slit-like recess between them called the *sinus of the epididymis* (Figs. 104, 105).

Testis.—The testis is an oval body with flattened sides. It varies considerably in size, but its average dimensions are an inch and a half in length, an inch in antero-posterior diameter, and rather less than that from side to side.

It is free, except where it is connected with the epididymis above and behind ; and it is covered everywhere by the visceral layer of the tunica vaginalis, except along its posterior border. Its *efferent ducts* issue from its upper end and enter the epididymis ; and its vessels and nerves pass through its posterior border. It lies at a slight tilt in the scrotum, its upper end being directed slightly forwards ; and the left testis, as a rule, hangs at a lower level than the right.

The *appendix of the testis* (Fig. 107) is a small, sessile, pear-shaped body found attached to the upper part of the anterior border of the testis. The *appendix of the epididymis* is a similar structure—a little larger and stalked—that may be found on the upper end of the epididymis. Both of them are remnants of embryonic structures.

Epididymis.—The epididymis is a comma-shaped structure which lies along the lateral part of the back of the testis, overlapping its summit. The upper end is enlarged and is known as the head of the epididymis; the lower end is the tail, and the intervening part is the body.

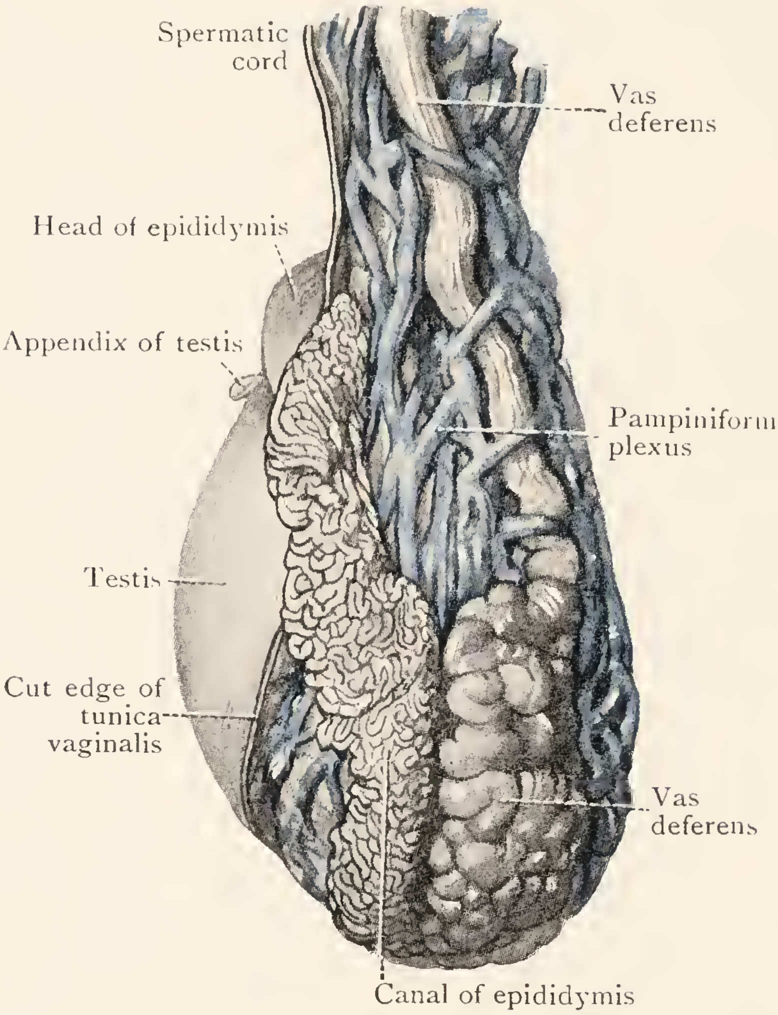


FIG. 107.—Left Testis and Epididymis seen from behind, after removal of parietal part of tunica vaginalis. (A. F. Dixon)

The *head of the epididymis* surmounts the upper end of the testis like a helmet, and is attached to it by the visceral layer of the tunica vaginalis and by the efferent ducts. The *tail of the epididymis* is fixed to the back of the testis by the tunica vaginalis and some areolar tissue. The *body of the epididymis* is separated from the testis by an involution of the tunica vaginalis which lines the *sinus of the epididymis*. Note that the epididymis lies towards the lateral side of the back of the testis; this fact is important in the diagnosis of swellings in the scrotum.

The *vas deferens* emerges from the tail of the epididymis and then passes upwards over the back of the testis along the medial side of the body and head of the epididymis.

Some of the main facts relating to the structure of the testis may be learned by a careful naked-eye examination of its different parts.

Dissection.—Fix the testis with pins in a cork-lined tray and dissect it under water. Trace the blood-vessels into the gland. Then, free the tail and body of the epididymis from the testis, and divide the testis transversely about its middle with a sharp knife.

Structure of Testis.—Study the cut surface of the lower part of the testis.

The dense, tough, fibrous coat which envelops it, under cover of the visceral layer of the tunica vaginalis, is the *tunica albuginea.* In the posterior part of the testis the tunica albuginea forms a longitudinal thickened ridge, called the *mediastinum testis*, which projects forwards into the interior of the gland. The mediastinum is traversed by the arteries, veins, and lymph-vessels of the testis, and, in addition, it is tunnelled by a network of seminal channels called the *rete testis.*

Note the radiating fibrous strands that pass through the substance of the testis from the front and sides of the mediastinum. They are the cut margins of incomplete fibrous septa which diverge to be connected with the tunica albuginea on the front and sides of the testis (Fig. 105). By means of these partitions, the space enclosed by the tunica albuginea becomes broken up into a large number of partially separated compartments—two to three hundred in number. The fibrous framework of the testis is therefore the tunica albuginea with the mediastinum testis and the septa.

The proper glandular substance of the testis is lodged within the compartments described above. It consists of four to six hundred fine, hair-like tubes termed the *convoluted seminiferous tubules*, each of which is over two feet (60 cm.) long. Two or more occupy each compartment, and constitute what is called a *lobe of the testis.* The tubules of each lobe are coiled and convoluted to an extraordinary degree, and the coils are surrounded and bound together by delicate areolar tissue.

As the convoluted tubules approach the mediastinum they join one another at acute angles and form a smaller number of tubes; these finally become straight and considerably reduced in diameter, and are named the *straight seminiferous* *tubules.* They enter the mediastinum and open into the *rete testis.*

Dissection.—Attempt to unravel some of the tubules of the testis, under water, with the aid of forceps and a probe. It will not be possible, under ordinary circumstances, to open them out fully, but a sufficiently good demonstration of their general arrangement may be made. Afterwards, remove the tubules from the lower part of the testis by the use of the forceps aided by a stream of water. A good view of the fibrous framework of the testis will then be obtained.

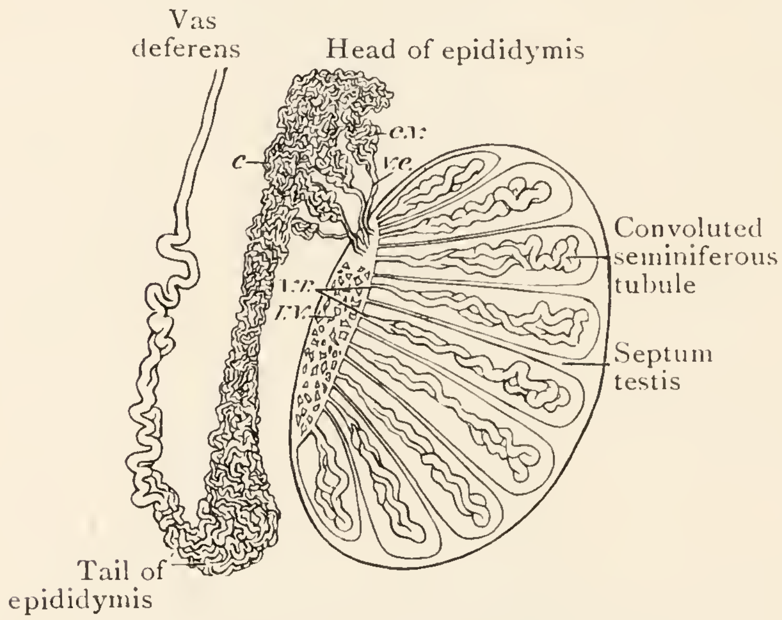


FIG. 108.—Diagram illustrating the Structure of Testis and Epididymis. (A. F. Dixon)

c. Canal of epididymis.
c.v. Lobules of epididymis.
v.e. Efferent ducts of testis.
v.r. Straight tubules.
r.v. Rete testis.

Next, examine the upper part of the testis (with the attached epididymis), and try to ascertain the manner in which the secretion of the testis passes from the rete testis into the epididymis. Divide the part of the tunica vaginalis that connects the testis with the head of the epididymis, gently separate those two parts, and explore the areolar tissue between them. Under favourable circumstances the *efferent ducts* may be seen passing from the testis into the epididymis.

Structure of Epididymis.—The *efferent ducts* of the testis are fifteen to twenty delicate tubes. They leave the upper part of the rete testis, and pass into the head of the epididymis, where they become spirally coiled and form a series of small conical masses called the *lobules of the epididymis.* Ultimately, the efferent ducts unite to form the commencement of a coiled tube termed the *canal of the epididymis.* The head of the epididymis is thus composed of the lobules of the epididymis and part of the coiled canal of the epididymis embedded in areolar tissue. The body and tail of the epididymis are formed of the continuation of the same canal, coiled and convoluted upon itself to a remarkable degree.

The intricacy of its flexuosities will be better understood if it is simply stated that were the tube completely opened out it would be found to measure twenty feet or more.

At the lower end of the epididymis the canal becomes continuous with the vas deferens.

Dissection.—The dissectors should endeavour to unravel a part of the canal of the epididymis. The coils are held together by areolar tissue, and the dissection is very tedious.

Penis.—The penis was studied, to a certain extent, when the perineum was dissected, and its main constituent parts—the *corpora cavernosa* and the *corpus spongiosum*—were partially examined (p. 161). It was noted also, at that time, that the corpora cavernosa separate and become the two crura of the penis, which are attached to the sides of the pubic arch. Anteriorly, the ends of the corpora cavernosa penis are separated by a small notch, and are embedded in the glans penis (Figs. 110, 113).

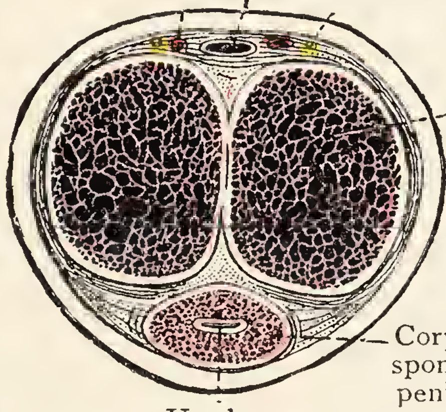


FIG. 109.—Transverse Section through Body of Penis.

The corpus spongiosum is expanded at each end. The posterior expanded part is the *bulb of the penis*, which is attached to the median part of the perineal membrane. The anterior expanded portion is the *glans penis*, which forms a cap over the anterior ends of the corpora cavernosa.

The glans penis is conical in shape and the projecting margin of its base is called the *corona glandis* ; the portion of the penis immediately behind the glans is called the *neck* of the penis.

The urethra traverses the whole length of the corpus spongiosum of the penis—entering the bulb, from above, at the perineal membrane, and terminating at the extremity of the glans as a vertical fissure called the *external orifice* of the urethra.

Skin and Fasciæ of Penis.—The *skin* is remarkable for its great delicacy and elasticity, and the absence of hairs over its greater part. It has a brownish tint, and is freely movable over the organ except on the glans. At the neck, the skin leaves the body of the penis, and is folded for a variable distance over the glans to form the *prepuce* (Figs. 113, 205). The deep layer of the prepuce reaches the penis again at the neck, and is then reflected forwards over the neck and the glans to become continuous with the mucous membrane of the urethra at its external orifice; the skin that clothes the glans is exceedingly thin, and so adherent that it cannot be removed without tearing the substance of the glans. A narrow, median fold of skin extends from the lower angle of the external urethral orifice to the deep layer of the lower part of the prepuce, and is called the *frenulum of the prepuce*. The greater part of the prepuce is removed in the operation of *circumcision* (Fig. 113).

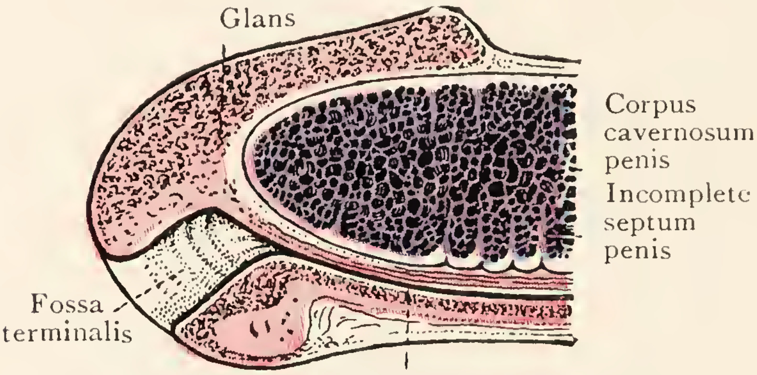


FIG. 110.—Median Section through terminal part of Penis.

The *superficial fascia* is a layer of areolar tissue loosely arranged to allow movement of the skin over the body; and it is devoid of fat. The underlying *deep fascia* forms a close-fitting sheath around the corpora.

Dissection.—Make a longitudinal incision along the dorsum of the penis from the pubic symphysis to the end of the prepuce, and reflect the skin to each side. Look for the *suspensory ligament* of the penis, and trace it from the symphysis to the penis; and then clean the *superficial dorsal vein*, which runs backwards in the median plane. Now, clear away the superficial fascia, and expose the deep fascia.

After the deep fascia has been examined, divide it along the median line on the dorsum of the penis. Immediately beneath it, in the median plane, find the *deep dorsal vein*. Clean the deep vein; at its sides find the *dorsal arteries* and *nerves* of the penis, and clean them.

The *suspensory ligament of the penis* is a strong fibro-elastic band of a triangular shape. By its posterior border it is attached to the pubic symphysis. Towards the penis it divides into a right and a left lamella, which separate and fuse with the deep fascia at the sides of the body of the organ. The dorsal vessels and nerves are placed between the two lamellæ (Fig. 101).

Dorsal Vessels and Nerves of Penis.—On the dorsum of the penis, a pair of dorsal nerves run lengthwise beneath the deep fascia; between them there is a pair of dorsal arteries separated by the deep dorsal vein, which lies in the median plane. The superficial dorsal vein—also median—lies in the superficial fascia, and is the one seen through the skin. Note that the veins are not right and left like the arteries and nerves, but are both median—a superficial and a deep.

The *superficial dorsal vein* receives tributaries from the skin, including the prepuce; and it terminates posteriorly by dividing into right and left branches which join the corresponding external pudendal veins in the thigh.

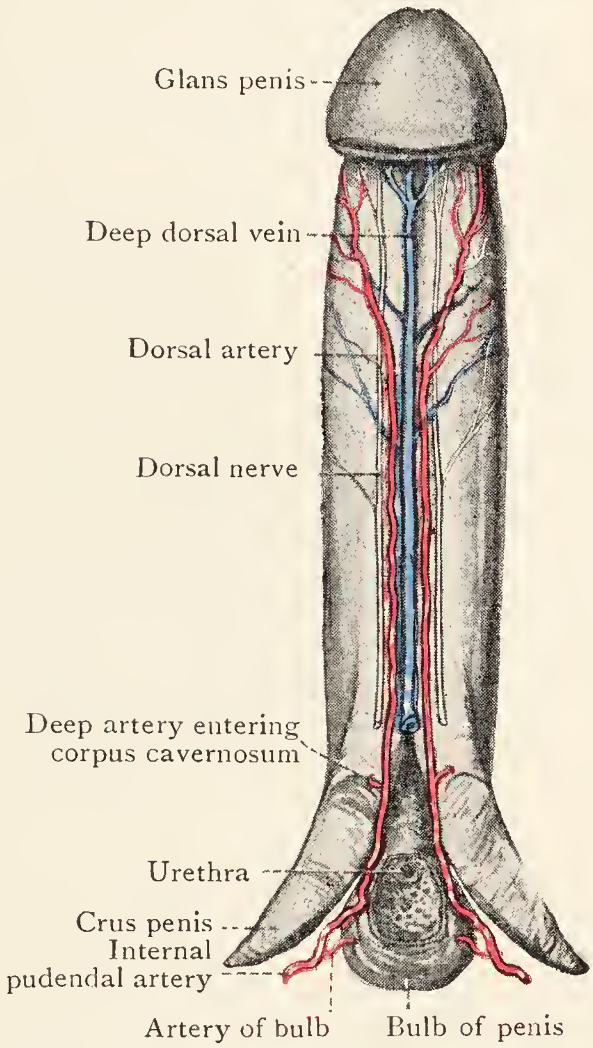


FIG. 111.—Dorsal surface of Penis, showing the main Blood-Vessels and Nerves.

The *deep dorsal vein* begins by the union of several twigs from the glans and prepuce. It extends backwards in the median line, passes between the two layers of the suspensory ligament, and enters the pelvis after passing below the inferior pubic ligament It ends by joining the venous plexus around the prostate.

Each *dorsal artery* is a terminal branch of the internal pudendal. It ascends between the crus and the pubic bone to reach the dorsum, where it passes between the two layers of the suspensory ligament, and then runs forwards supplying the skin; and it ends in branches to the glans penis.

Each *dorsal nerve* is a terminal branch of the pudendal nerve. It runs along the lateral side of the artery, gives twigs to the skin, and ends in fine twigs to the papillæ of the glans.

Dissection.—Make a transverse section through the body of the penis, but leave the skin on the urethral surface undivided in order that the two segments of the divided organ may remain connected until the urethra has been examined at a later stage. Now, examine the naked-eye structure of the divided parts.

Structure of Penis.—The corpora cavernosa of the penis are a pair of elongated bodies each consisting of cavernous

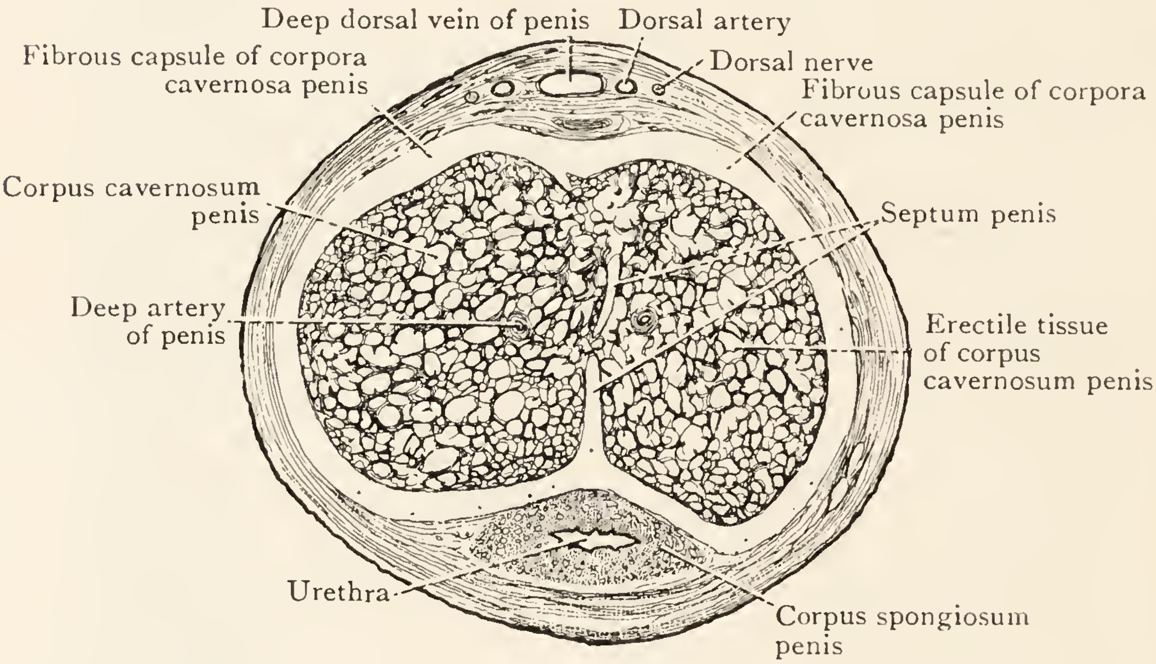


FIG. 112.—Transverse Section through anterior part of Body of Penis to show its structure.

erectile tissue filled with blood and surrounded by a dense, adherent, white fibrous capsule. The medial sides of their capsules are imperfect, and are fused together in the median plane to form what is called the *septum penis*. The septum is interrupted by numerous clefts through which the spaces of the right and left corpora cavernosa communicate; the clefts may be seen if the erectile tissue is dissected away from the septum for a short distance on one side. In the centre of each corpus cavernosum the *deep artery* of the penis may be seen.

The corpus spongiosum of the penis also consists of erectile tissue, but the meshes of the spongework are finer than those of the corpora cavernosa, and the fibrous capsule is thinner and less dense. In the centre of the corpus spongiosum the *urethra* will be seen. In a well-injected specimen, a pair of small arteries also will be seen : they are the *arteries of the bulb.*

Note that in a transverse section of the penis three pairs of arteries are met with—the dorsal arteries, the deep arteries and the arteries of the bulb of the penis.

Dissection of Loin and Exposure of Kidney

On the sixth day after the body was placed on its back it will be turned on its face, with blocks supporting the thorax and pelvis ; and in that position it will remain for five days.

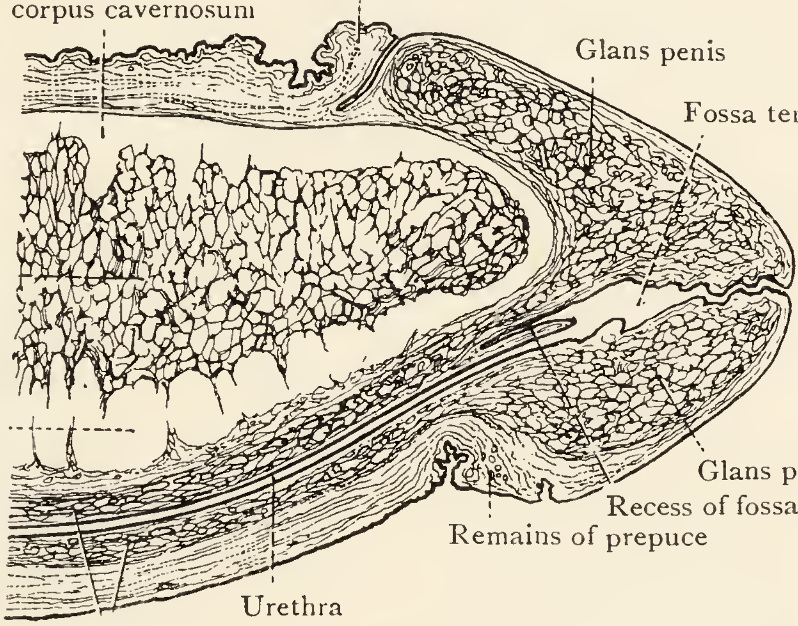


FIG. 113.—Median Section through terminal part of (circumcised) Penis to show its structure.

At the beginning of the second day of the period, after the dissectors of the Upper Limbs have cleaned the latissimus dorsi, the dissectors of the Abdomen take the opportunity of examining the posterior border of the external oblique.

Lumbar Triangle.—The posterior border of the external oblique muscle passes from the last rib to the outer lip of the iliac crest, and is quite free. There is often a small triangular interval between it and the lower part of the latissimus dorsi. That interval is called the *lumbar triangle* ; and, if the fat is cleared out of it, its floor will be found to be formed of fibres of the internal oblique or the fascia covering the quadratus lumborum—or partly of both. The triangle is a comparatively weak region of the abdominal wall ; and, in some rare cases, hernia of the abdominal contents occurs through it. Not uncommonly, however, the lateral border of the latissimus dorsi overlaps the posterior border of the external oblique, and then the lumbar triangle does not exist.

Lumbar Fascia.—On the third day (the dissectors of the Upper Limbs having now reflected the muscles which connect the limbs with the back of the trunk), the dissectors of the Abdomen, in association with the dissectors of the Head and Neck, examine the lumbar fascia and the lumbar origins of the internal oblique and the transversus abdominis muscles.

The lumbar fascia binds down the deep muscles of the back at the sides of the spines of the vertebræ. Although called "lumbar," because it is most important in that region, it extends from the sacrum to the neck. In the *thoracic region* it is a thin, transparent lamina which passes from the spines of the vertebræ to the angles of the ribs. At the upper end of the thoracic region it disappears under cover of a thin muscle called the serratus posterior superior, and then enters the neck. In the *sacral region*, it stretches from the sacral spines to the ilium and the sacro-tuberous ligament; and it ends inferiorly by being attached to the back of the sacrum and the coccyx.

In the *lumbar region*, it is much stronger and is divided into three layers—anterior, middle and posterior. The anterior and middle layers enclose the quadratus lumborum muscle, which lies alongside the tips of the lumbar transverse processes; the posterior layer covers the massive part of the sacro-spinalis which lies in the loin alongside the lumbar spines, covering the transverse processes and overlapping the quadratus lumborum. This layer gives origin to a part of the *latissimus dorsi* and to a thin muscle called the *serratus posterior inferior* which underlies the latissimus, and stretches upwards and laterally from the lumbar fascia to the lower three or four ribs; at this stage, the serratus inferior has been cleaned by the dissectors of the Head and Neck.

The dissectors of the Abdomen will now proceed to display the layers of the lumbar fascia.

> ***Dissection.***—Take away the remains of the origin of the latissimus dorsi. Divide the serratus posterior inferior at right angles to its fibres; turn the two parts aside, looking for its nerves; and then remove the part attached to the lumbar fascia.

The *posterior layer* of the lumbar fascia is now exposed.

It is much the strongest of the three layers, and is dense and tendinous in character. It is continuous superiorly with the thoracic part of the fascia, and inferiorly with the sacral part. Medially, it is attached to the lumbar spines and supraspinous ligaments. Laterally, it blends with the middle layer at the lateral margin of the sacro-spinalis.

Dissection.—Make a vertical incision through the middle of the posterior layer from the last rib to the iliac crest, and cross-cuts at its ends—taking care to stop at the margin of the sacro-

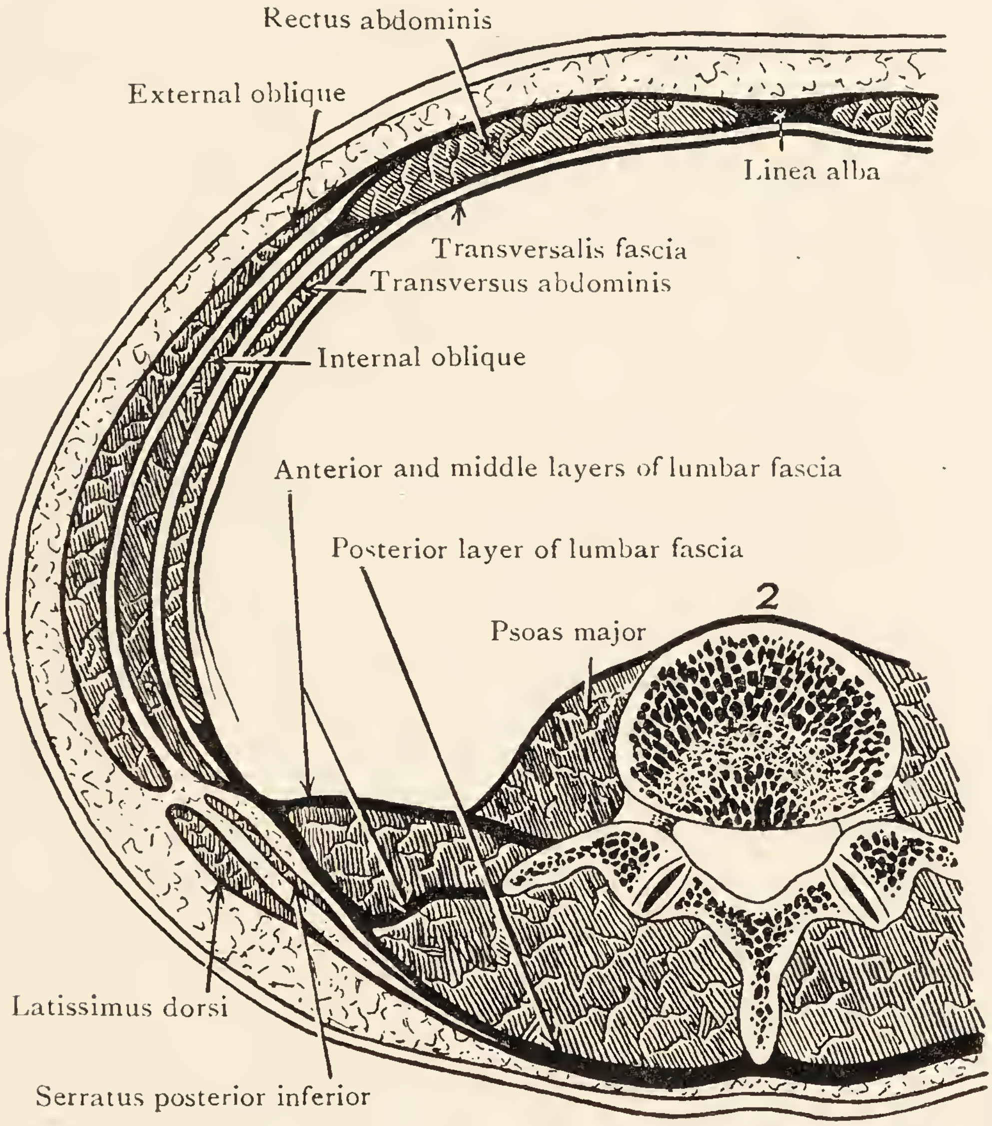


FIG. 114.—Diagram of Lumbar Fascia.

spinalis. Reflect the two parts, and examine their attachments. Push the sacro-spinalis medially, and, with the fingers, follow the middle layer of the fascia to its attachments above and below and medially.

The *middle layer* clothes the back of the quadratus lumborum, and separates that muscle from the sacro-spinalis. Its posterior surface fuses with the posterior layer at the lateral margin of the sacro-spinalis, and, immediately lateral to the line of fusion, it gives origin to the uppermost fibres of the internal oblique muscle. It is attached medially to the lumbar transverse processes, superiorly to the last rib, and inferiorly to the iliac crest and to a strong fibrous band, called the *ilio-lumbar ligament*, which stretches from the iliac crest to the fifth lumbar transverse process. Laterally, it unites with the anterior layer at the lateral margin of the quadratus lumborum to form a band that stretches from the last rib to the iliac crest and gives origin to the middle part of the transversus abdominis muscle.

Dissection.—Divide the middle layer along its upper, lower and medial attachments, and reflect it laterally. Push the quadratus lumborum medially to expose the anterior layer of the fascia, and run the fingers over that layer to its various attachments.

The *anterior layer* of the lumbar fascia is a thin (but fairly strong) membrane that clothes the front of the quadratus lumborum, at whose lateral margin it unites with the middle layer. It is attached medially to the front of the lumbar transverse processes near their tips, inferiorly to the iliac crest and the ilio-lumbar ligament, and superiorly to the last rib. To reach the last rib, the quadratus and the two layers of fascia that enclose it have to pass upwards behind a portion of the diaphragm. Near the last rib, the anterior layer fuses with a tendinous band which gives origin to that portion of the diaphragm. The band is called the *lateral arcuate ligament* (arcus lumbo-costalis lateralis) (p. 374).

Exposure of Kidney.—The dissectors will now complete the dissection for the exposure of the kidney.

Dissection.—Divide the anterior layer of lumbar fascia longitudinally. Pass the finger through it, scrape away the fat and expose the back of the kidney and the structures near it.

The structures to be looked for in this dissection are :—

(1) The *subcostal vessels* and *nerve*, behind the kidney, immediately below the last rib ; (2) the *ilio-hypogastric* and *ilio-inguinal nerves*, lower down ; and (3) at the lateral margin of the kidney, a part of the *colon*, and the *liver* on the right side, the *spleen* on the left side. For the posterior relations of the kidney see p. 364, and Figs. 182-184.

The dissectors of the abdomen now discontinue dissection until the body is turned on its back again. They will then re-examine the inguinal region and study the anatomy of *hernia*; and they will afterwards proceed to investigate the cavity of the abdomen and its contents.

HERNIA

The anatomy of the regions where hernia most frequently occurs is of such great importance to the surgeon that special attention must be paid to it by the dissectors.

Hernia is the term applied to the abnormal protrusion of any of the contents of the abdomen through its wall. The commonest of the contents of abdominal herniæ is a portion of small intestine or a portion of the fold of peritoneum known as the greater omentum.

In making its way to the exterior, the protrusion pushes the parietal peritoneum before it. This envelope of peritoneum is called the *sac* of the hernia; and the proximal end of the sac is its *neck*. The protruding viscus is called the *contents* of the hernia; and the *coverings* are all the structures that separate the sac from the exterior.

Abdominal hernia occurs most commonly where a diverticulum of the peritoneum was prolonged through the abdominal wall at some period of intra-uterine development. The two situations in which such prolongations are always present are the inguinal region and the umbilicus; and a small diverticulum is often met with in the subinguinal region, dipping into the mouth of the femoral canal. Herniæ are therefore most common in those three regions, and they are distinguished as *inguinal*, *umbilical* and *femoral* hernia.

Inguinal Hernia.—Inguinal hernia may occur in the female but it is much more common in the male because the inguinal canal is wider, and because the diverticulum of peritoneum (the *processus vaginalis*) which existed in the inguinal region and passed obliquely through the wall of the abdomen to produce the inguinal canal is fully developed only in the male; and, although the diverticulum usually disappears in the male as well as in the female, the canal made by its passage may, to a certain extent, be looked upon as a source of weakness to the part of the wall through which it runs. The weakness, however, is more apparent than real, for the canal is so oblique in the adult that its abdominal opening (*deep inguinal ring*) is an inch and a half distant from its external opening (*superficial inguinal ring*); the canal is therefore valvular, and the intra-abdominal pressure, forcing the walls together, tends to close it; moreover, the constituent parts of the anterior and posterior walls are so arranged that the thicker part of one wall is opposite the thinner part of the other wall; the walls of the canal are therefore well-adapted to resist the effects of intra-abdominal pressure. The student must realise, however, as a practical point, that the contents of the abdomen may be looked upon as being of a fluid or semi-fluid nature; consequently, if a portion of the abdominal contents happens to bulge into the inguinal canal either through the deep ring or through a weak spot in the posterior wall of the canal, the action of the abdominal pressure will thenceforth tend to distend the inguinal canal and force the abdominal contents farther and farther along it till eventually they pass right through it.

The dissectors will now make a special dissection of the inguinal region on the left side of the body—kept intact for the purpose.

Dissection.—Begin by reflecting the aponeurosis of the external oblique. Make a vertical incision through it, parallel to the lateral border of the rectus abdominis, and carry it downwards medial to the superficial inguinal ring. The aponeurosis can then be thrown downwards and laterally; and, at the same time, the ring is preserved. Clean the internal oblique and the conjoint tendon, and study their precise relations to the spermatic cord or the round ligament of the uterus:—the lower fleshy bundles of the internal oblique are in front of the lateral part of the cord or the ligament, but, towards the outlet of the canal, the conjoint tendon is behind it.

Next, replace the aponeurosis of the external oblique, and introduce the point of the forefinger into the superficial ring and press directly backwards. The finger rests on the *conjoint tendon*, and is separated from the extra-peritoneal fat by that tendon and the *transversalis fascia*. If the *reflected part of the inguinal ligament* is well developed, it will intervene between the finger and the conjoint tendon. Separate the lower part of the internal oblique from the transversus by insinuating the handle of the knife between them; divide the internal oblique close to the inguinal ligament, and throw it medially. Then, in the male, make a longitudinal incision through the cremaster muscle, and turn it aside from the surface of the cord.

All further dissection must be effected from the inside. Divide the abdominal wall, from side to side, at the level of the umbilicus. Raise the lower part, and examine the back of it.

When the back of the lower part of the anterior wall of the abdomen is examined, five longitudinal ridges of peritoneum are seen—one median and two on each side. These ridges are produced by the umbilical ligaments and the inferior epigastric vessels (Fig. 116).

Umbilical Ligaments.—The median ridge of peritoneum encloses a slender fibrous cord, called the *median umbilical ligament*, which is a remnant of the urachus of the embryo ; it extends upwards from the apex of the urinary bladder, between the peritoneum and the transversalis fascia, and ends at the umbilicus. On each side of the median ridge, there is an oblique ridge of peritoneum produced by a slender cord called the *lateral umbilical ligament*. That ligament stretches from the pelvis to the umbilicus and is the obliterated part of a vessel called the umbilical artery which springs from the internal iliac, and, in the fœtus, carries the blood to the placenta. As it ascends out of the pelvis, it is behind the inguinal canal near its medial end ; the lower part of the shallow fossa between the lateral and median ligaments is therefore opposite the superficial inguinal ring.

Inferior Epigastric Artery.—This artery, as it runs with its companion veins towards the rectus abdominis, raises a ridge of peritoneum which is still more laterally placed. Its lower part is behind the inguinal canal close to the deep ring. The lower part of the depression on its lateral side is therefore opposite the ring. The lower part of the fossa between it and the lateral umbilical ligament is opposite the part of the posterior wall of the canal which is formed of the transversalis fascia alone ; this portion of the fossa is sometimes fairly deep, and its depth may predispose to the kind of hernia called a direct inguinal hernia.

Dissection.—Divide the lower part of the abdominal wall along the linea alba a little on one side of the median umbilical ligament, and, when approaching the pubic symphysis, be careful not to injure the urinary bladder, for it may bulge upwards above the symphysis. When the left flap is thrown downwards and laterally, it may be possible to detect the position of the deep inguinal ring from the fact that the peritoneum is sometimes slightly dimpled into it. Now, strip the peritoneum from the flap with the fingers as far down as the inguinal ligament, and separate the extraperitoneal tissue from the fascia transversalis with the handle of the knife, proceeding with great care as the inguinal ligament is approached. The *deep inguinal ring* is now exposed from behind.

Deep Inguinal Ring.—Note that the deep ring, when seen from behind, appears to be a vertical slit rather than a round opening, and that its lower and lateral margins are thicker than the others. Note also the round ligament or the vas deferens and the testicular vessels entering it, and the inferior epigastric vessels passing obliquely near its medial margin. If it is a male body, pass the tip of the little finger into the ring, push it gently along the canal, and then raise the flap of abdominal wall and look at it from the front : a striking demonstration of the internal spermatic fascia is obtained.

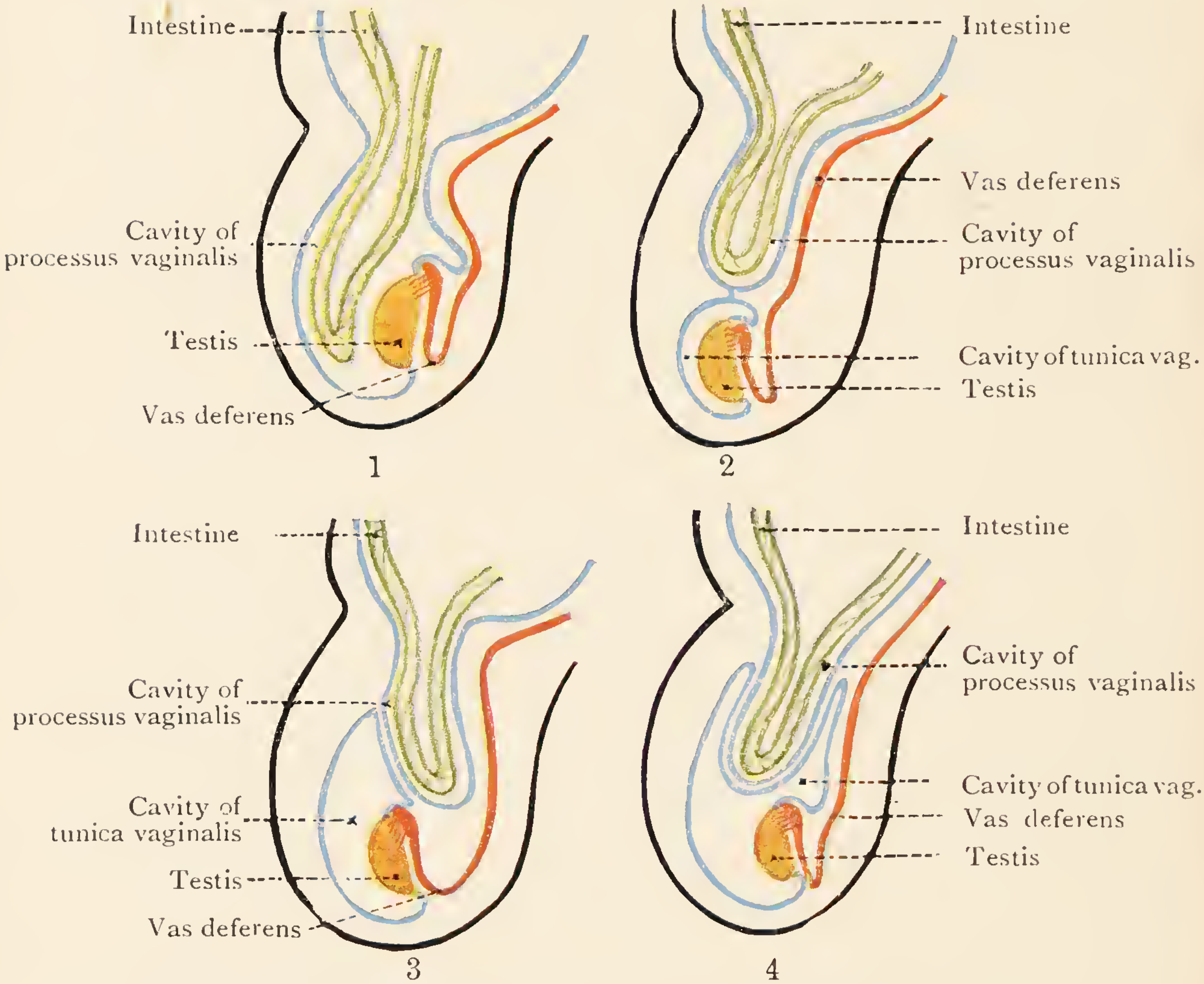


FIG. 115.—Diagrams of different forms of Scrotal Herniæ. Cf. Fig. 103.

In order to understand more clearly the account of the different kinds of hernia, turn back to p. 206 and read again the account given of the formation and boundaries of the inguinal canal, and, from the dissection now made, confirm the statements in it ; re-read also the description of the processus vaginalis on pp. 214, 215.

Direct Inguinal Hernia.—Such a hernia is one that passes directly into the inguinal canal through its posterior wall, either between the lateral umbilical ligament and the rectus abdominis muscle or between the ligament and the inferior epigastric vessels. It is due either to the slow distension of a weak spot in the posterior wall of the canal under the influence of intra-abdominal pressure or to a rupture at the weak spot by a sudden increase of the pressure. After the pouch of peritoneum (containing a viscus) has stretched the posterior wall or burst through it, the action of the intra-abdominal pressure tends to force the protrusion along the line of least resistance—and that is usually along the canal towards the superficial inguinal ring.

A direct hernia occurs in elderly people ; it does not reach far beyond the superficial ring ; and it pushes the round ligament or the spermatic cord and internal spermatic fascia towards the lateral side of the ring.

The *coverings* of a direct hernia vary according to (1) whether it is lateral or medial to the lateral umbilical ligament when it impinges on the posterior wall of the canal and (2) whether it tears the wall or stretches it and bulges it forwards as a covering.

When it stretches the wall and if it is lateral to the ligament, the coverings are :—(1) extraperitoneal tissue ; (2) transversalis fascia ; (3) cremaster muscle and fascia (only in the male) ; (4) external spermatic fascia (negligible in the female) ; (5) two layers of superficial fascia ; (6) skin. If it is medial to the ligament, it is opposite the superficial ring, and its coverings are :—(1) extraperitoneal tissue ; (2) transversalis fascia ; (3) conjoint tendon ; (4) external spermatic fascia ; (5) two layers of superficial fascia ; (6) skin.

In a hernia that bursts through the posterior wall, the transversalis fascia and the conjoint tendon are absent as coverings ; otherwise, the coverings are the same as those given above.

Oblique Inguinal Hernia.—This kind is much more common than the direct. In the oblique variety, the hernial protrusion passes through the deep inguinal ring, traverses the inguinal canal, and, after its exit through the superficial ring, it may descend into the labium majus or the scrotum, and often does so.

It is important to note the following difference between a direct and an oblique inguinal hernia :—In the *direct* kind, the inferior epigastric vessels are lateral to the neck of the sac.

Since an *oblique* hernia passes into the deep ring, the vessels are medial to the neck of its sac.

An oblique inguinal hernia in the female is similar in origin to the less common kind of oblique hernia in the male. This variety of hernia results from a dimpling of the peritoneum into the deep inguinal ring. A portion of a viscus is pressed into the dimple, and, stretching and pushing the peritoneum before it, it passes through the inguinal canal and then downwards towards the labium majus or the scrotum, and may reach that level.

Its *coverings* in the female are :—(1) extraperitoneal tissue ; (2) external spermatic fascia (negligible) ; (3) two layers of superficial fascia ; (4) skin. (The sheath of transversalis fascia given to the round ligament from the margins of the deep ring is a covering theoretically, but it is probably ruptured, and, in any case, is negligible). In the male the coverings are :—(1) extraperitoneal tissue ; (2) internal spermatic fascia ; (3) cremaster muscle and fascia ; (4) external spermatic fascia ; (5) two layers of superficial fascia ; and (6) skin.

The commoner variety of oblique inguinal hernia is due to the persistence of the processus vaginalis. It occurs therefore only in the male. The sac of the hernia is the persisting processus vaginalis ; and its coverings are the same as those given above.

If the cavity of the persisting processus vaginalis is still continuous with the cavity of the tunica vaginalis of the testis, the herniated viscus will enter the tunica vaginalis (Fig. 115, 1) ; but, if the processus has been separated from the tunica by a septum (Fig. 115, 2), the processus (with its contained hernia) may be forced downwards either in front of the tunica or behind it (Fig. 115, 3) ; or the processus may invaginate the tunica (Fig. 115, 4). Herniæ differentiated from each other by the relation which the processus bears to the tunica vaginalis are described by surgeons under special names which the student will find explained in Manuals of Surgery.

Femoral Hernia.—A femoral hernia is the protrusion of a part of the gut or some other part of the abdominal contents into the thigh, and is more common in women than in men. In its descent it passes *behind* the inguinal ligament into the *femoral canal.* It is consequently mainly the duty of the dissectors of the Lower Limb to investigate the anatomical relations of this variety of hernia (Vol. I. p. 218). Still, it is essential that the dissectors of the Abdomen should examine the *femoral ring* from its abdominal aspect, and also give the dissectors of the Lower Limb an opportunity of doing so.

The *femoral ring* is the upper end of the femoral canal, and through it the abdominal cavity communicates with the

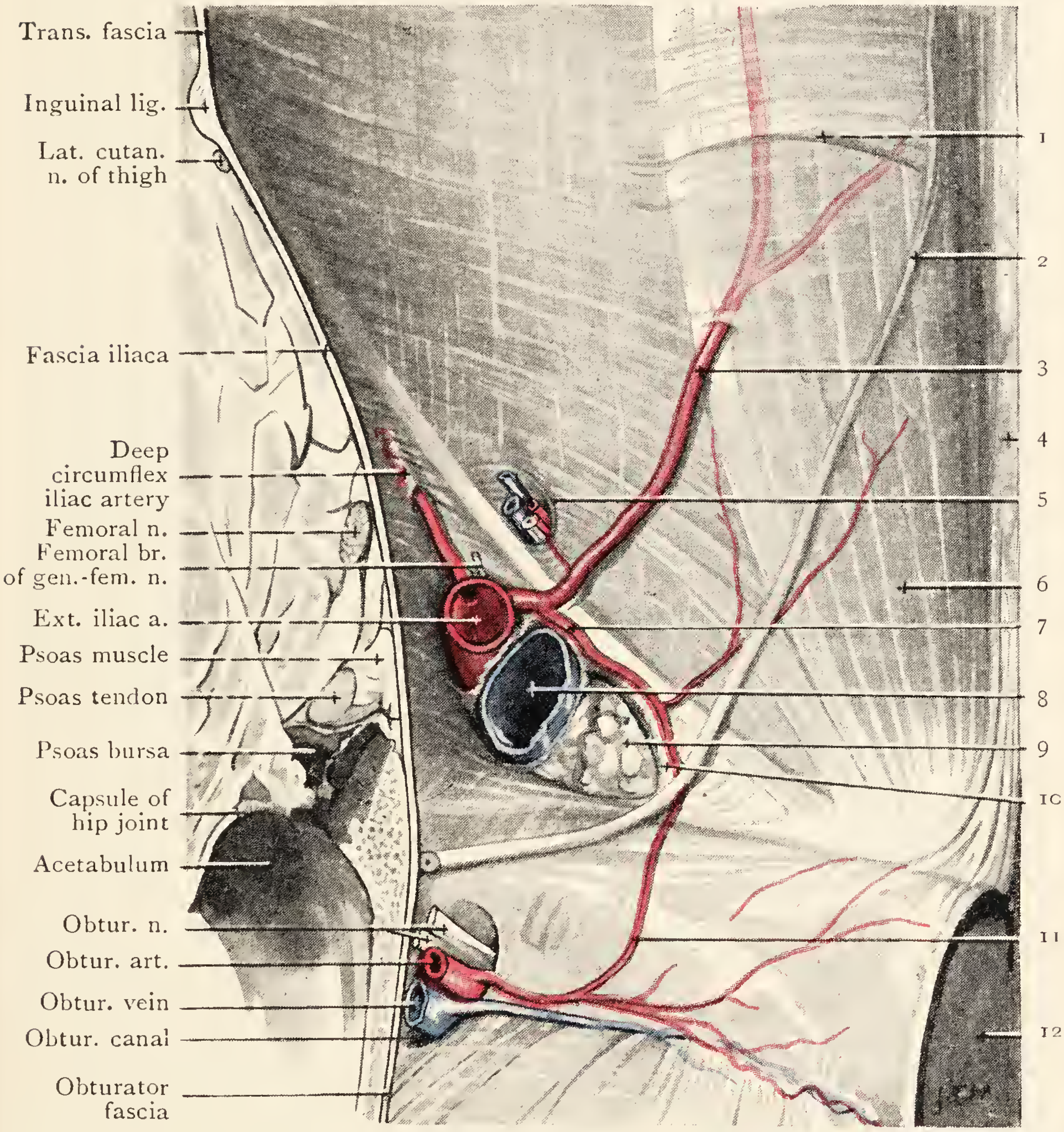


FIG. 116.—Deep Inguinal Ring, Femoral Ring and Obturator Canal, seen from inside the abdomen.

1. Arcuate line.
2. Lateral umbilical ligament.
3. Inferior epigastric artery.
4. Linea alba.
5. Deep inguinal ring.
6. Fascia transversalis behind rectus abdominis.
7. Pubic branch of inf. epigastric artery.
8. External iliac vein.
9. Fat in femoral canal.
10. Pectineal part of inguinal ligament, covered by transversalis fascia.
11. Pubic branch of obturator artery.
12. Pubic symphysis.

canal. It is placed immediately behind the inguinal ligament, between the base of its pectineal part and the external iliac vein; it is therefore at a lower level than the inguinal canal. If the peritoneum is still in position at that point, it may be slightly dimpled as it passes over the ring. Strip the peritoneum from the greater part of the iliac fossa. The portion of extraperitoneal tissue that stretches across the femoral ring is denser, stronger, and more fibrous than elsewhere; it closes the femoral canal at its abdominal end, and is called the *femoral septum*.

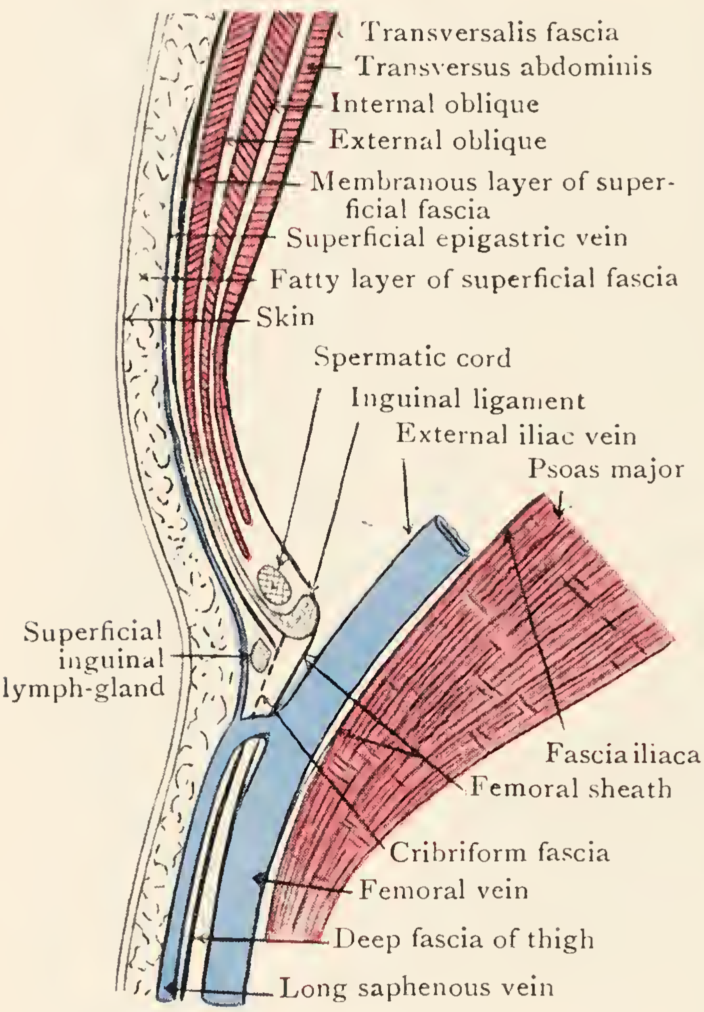


FIG. 117.—Diagram of Fasciæ and Muscles of Inguinal and Subinguinal Regions in the line of the Femoral Vein.

Dissection. — With the handle of the knife, dissect away the extraperitoneal fatty tissue in the area from which the peritoneum has been displaced. The *fascia iliaca*, which covers the iliacus and psoas muscles, will then be exposed; and the dissectors should note that the external iliac vessels lie *inside* and not *outside* that fascia.

The dissectors are now in a position to study the manner in which the *femoral ring* is formed. They should follow the fascia iliaca and the fascia transversalis towards the inguinal ligament. If the dissection has been carefully done, it will be obvious that these two fasciæ become directly continuous with each other at the part of the inguinal ligament that is lateral to the external iliac vessels, and, further, that along the line of union they are both firmly attached to the inguinal ligament. It is evident, then, that no hernial protrusion could leave the abdominal cavity behind the inguinal ligament lateral to the iliac vessels (Fig. 116).

In the region of the iliac vessels, the arrangement of the fasciæ will be found to be different. There, they both pass downwards behind the inguinal ligament—the fascia transversalis in front of the vessels, the fascia iliaca behind them (Fig. 117). In the thigh the two fasciæ thus form a funnel-shaped sheath for the femoral artery and vein. The sheath is divided into three compartments by two antero-posterior partitions. The femoral artery occupies the lateral compartment, the vein the intermediate compartment, and the medial compartment, called the *femoral canal*, is occupied by fat, by the lymph-vessels ascending to the abdomen, and, sometimes, by a small lymph-gland. (See also Vol. I. p. 217).

An essential difference between the compartments is that the lateral two are completely filled up by the artery and vein, while the contents of the femoral canal are loosely arranged and easily compressed. Gauge the width of the femoral ring by introducing the point of the little finger. It is readily admitted into the opening. Here, then, is a source of weakness to the abdominal wall, and one which is greater in the female than in the male, seeing that the distance between the iliac spine and pubic tubercle is relatively greater in the female, and, in consequence, the femoral ring wider.

When the finger is in the ring, mark the structures which surround it:—*anteriorly*, the inguinal ligament, with the spermatic cord or the round ligament of the uterus above it; *posteriorly*, the ramus of the pubis, giving origin to the pectineus muscle covered with its fascia; *medially*, the sharp and crescentic free border of the pectineal part of the inguinal ligament; and *laterally*, the external iliac vein.

It is still more necessary to note the relations of the blood-vessels to the femoral ring. The *external iliac vein* has been seen to lie to its lateral side. The *inferior epigastric artery*, as it ascends on the back of the abdominal wall, sends its *pubic branch* medially in front of the ring. More important than any of those relations is the relation of the *obturator artery* when it takes origin from the inferior epigastric. That abnormal vessel may adopt one of three courses:—(1) It may pass downwards and backwards across the femoral ring. (2) It may pass between the ring and the external iliac vein (*vide* Vol. I. p. 219). (3) It may follow the course of the pubic artery (of which it is in reality an enlarged form) and pass medially *in front* of the ring, and then descend along its *medial* margin ; in that case, the ring is surrounded by important vessels on all sides, except posteriorly.

Femoral hernia is more common in females, and inguinal hernia in males ; and for the very evident reasons that the femoral ring is larger in the female, and that the passage of the spermatic cord in the male weakens the inguinal region more than the passage of the round ligament does in the female.

Umbilical Hernia.—The umbilicus is usually a very strong part of the abdominal wall, on account of the scar-tissue formed there after birth (see pp. 178, 203). But it marks the position where, during part of intra-uterine life, the peritoneal cavity and a portion of gut were prolonged through the abdominal wall into the root of the umbilical cord. Long before birth the gut is withdrawn into the abdomen and the protruded peritoneal sac shrinks and disappears ; but, if the proximal part of the sac persists after birth in the substance of the abdominal wall, the wall is weakened and a portion of the abdominal contents may be forced into the diverticulum, causing its distension and producing an umbilical hernia. The anatomical coverings of the sac, from within outwards, would be :—(1) the stretched linea alba, (2) superficial fascia, (3) skin.

If the fœtal condition persists until birth, a portion of the gut lies in the umbilical cord, constituting a *congenital umbilical hernia* ; and cases have been known in which the bowel has been cut when the cord was divided at birth.

CAVITY OF ABDOMEN

When the dissectors have completed the examination of the regions where hernia occurs most commonly, they will proceed to study the cavity of the abdomen and its contents.

Subdivisions of Abdomen.—The abdomen, as a whole, is divided into the *abdomen proper* and the *pelvis*. Their cavities, however, are directly continuous with each other, for the plane of separation is the imaginary plane of the inlet of the bony true pelvis. The cavity of the abdomen proper extends from the roof of the abdomen to the inlet of the pelvis. The cavity of the pelvis is not in line with the cavity of the abdomen, but is behind its lower part as well as below it (Fig. 118).

The **cavity of the abdomen proper** is artificially divided into three zones—costal, umbilical, and hypogastric—by two imaginary horizontal planes. The upper of these is called the *subcostal plane*, and corresponds to a surface line drawn round the trunk at the level of the lowest part of the costal margin seen or felt when the body is examined from the front—and that is usually at the lower margin of the tenth costal cartilage (Fig. 120). The lower plane is called the *intertubercular plane*, for it corresponds to a surface line at the level of the tubercle of the iliac crest, which is at the most lateral part of the false pelvis and is therefore the highest point seen or felt on the iliac crest when the body is examined from the front. Each zone is divided into three parts by a pair of *vertical planes* opposite lines drawn up from the right and left mid-inguinal points. The costal zone is thus divided into a right and a left *hypochondrium* separated by the *epigastrium*; the umbilical zone into right and left *lumbar regions* and an *umbilical region*; and the hypogastric zone into right and left *iliac regions* and the *suprapubic region* or hypogastrium (Figs. 118, 119).

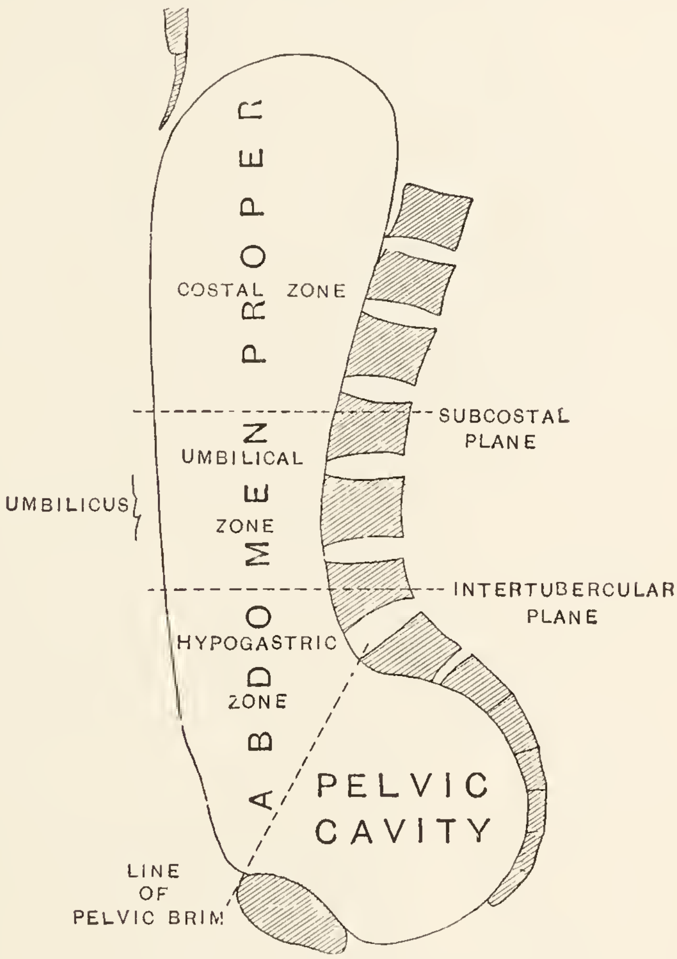


FIG. 118.— Outline of Abdominal Cavity as seen in Median Section.

This plan of dividing the cavity of the abdomen proper into nine regions is useful for occasional reference in defining the position of an organ or the seat of a malady; but its systematic use should be avoided, since it complicates rather than simplifies the description of the position of organs. The lines that correspond to the planes are, however, useful as artificial landmarks for some of the organs:—The *intertubercular plane* passes through the large intestine at the junction

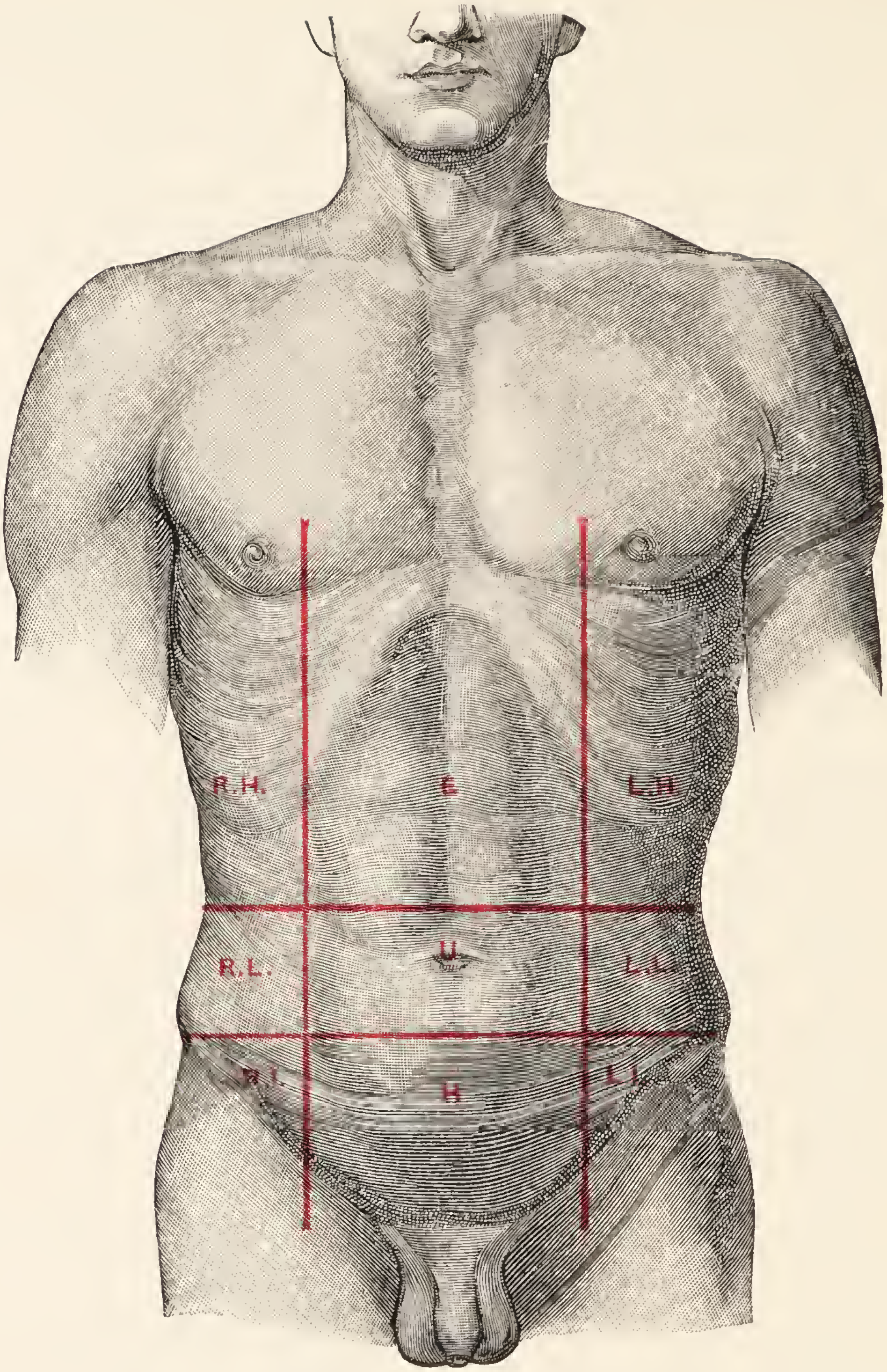


FIG. 119.—Planes of Subdivision of the Abdominal Cavity.

R.H. Right hypochondrium.
R.L. Right lumbar region.
R.I. Right iliac region.
E. Epigastrium.
U. Umbilical region.
H. Suprapubic region.
L.H. Left hypochondrium.
L.L. Left lumbar region.
L.I. Left iliac region.

of the cæcum and ascending colon, and, as it cuts the body of the fifth lumbar vertebra, it is a guide to the level of the structures related to that vertebra. The *subcostal plane* cuts the body of the third lumbar vertebra and the structures related to it.

Transpyloric Plane.—This is a still more useful plane, though it is not employed in the division of the abdomen into regions. It corresponds to a line drawn round the trunk at a level midway between the pubic symphysis and the upper

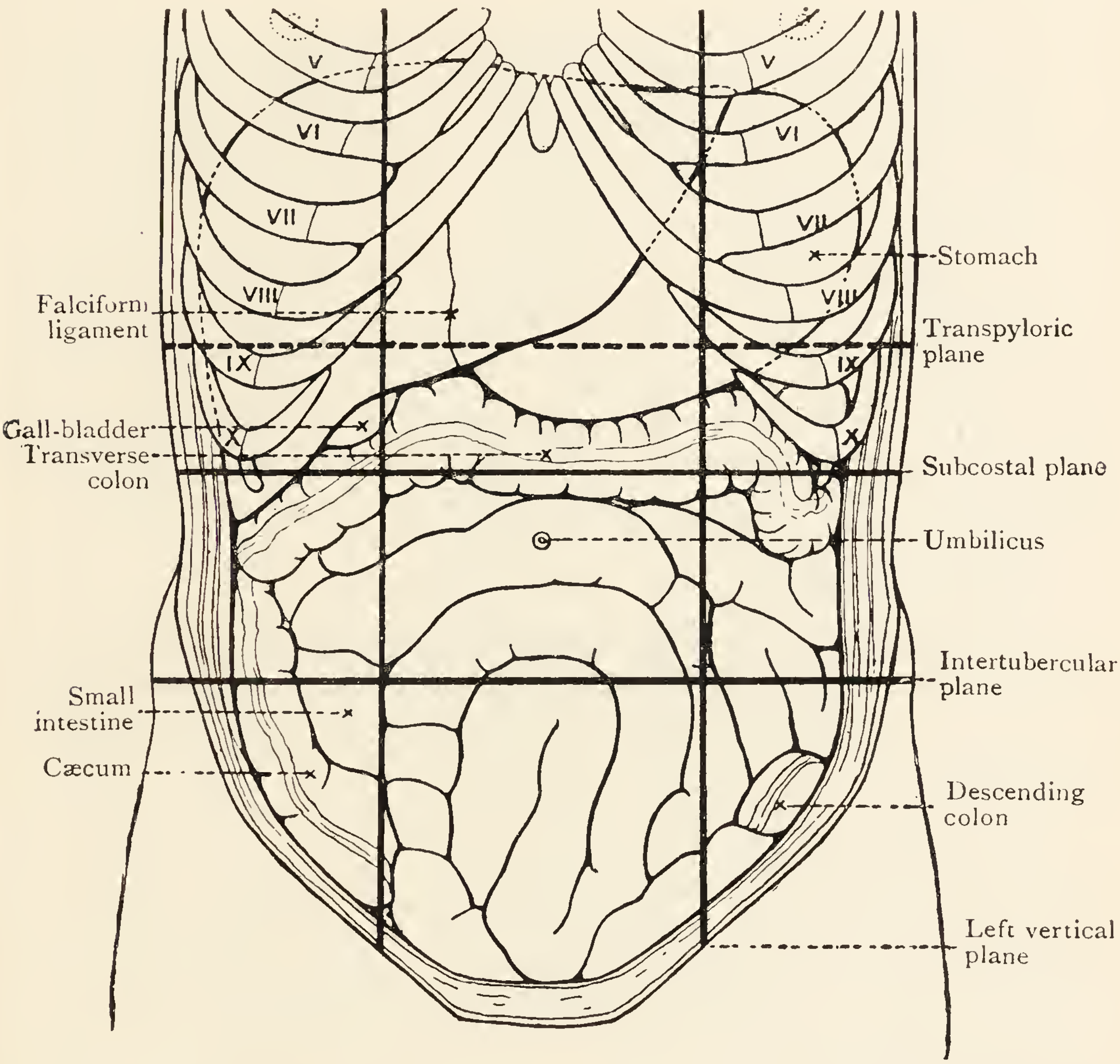


FIG. 120.—Abdominal Viscera, as seen from the front, after removal of greater omentum. The dark lines indicate the subdivision of the abdominal cavity (Birmingham). Note that in this specimen the 8th costal cartilage joins the sternum, and that the lower border of liver and the gall-bladder are a little lower than usual.

margin of the manubrium sterni—or, as a rough gauge, a hand's breadth below the xiphi-sternal joint. It cuts the first lumbar vertebra, and usually passes through the ninth costal cartilage and the upper end of the linea semilunaris. It also indicates fairly definite points of several of the organs —the fundus of the gall-bladder, the *pylorus* of the stomach, the middle of the left kidney, the neck of the pancreas, the commencement of the portal vein, and the origin of the superior mesenteric artery.

The dissectors will now open up the abdomen fully, note its shape and boundaries, and begin the examination of its contents.

Dissection.—The lower half of the abdominal wall has been divided and turned aside. Now, carry an incision upwards from the umbilicus to the xiphoid process immediately to the left of the median plane, and throw the two flaps upwards and laterally over the lower margin of the thorax.

Exposure of Falciform Ligament.—As the right flap is turned upwards, a wide fold (*i.e.* a double layer) of peritoneum will be seen extending from the flap to the liver. This fold is called the *falciform ligament* of the liver; at its free edge, its two layers are continuous with each other and enclose a slender fibrous band, named the *round ligament* (ligamentum teres) *of the liver*, which runs from the umbilicus to the liver.

Shape of Cavity of Abdomen (Figs. 120, 125, 126).—It has been explained already that the cavity of the abdomen is the space enclosed by the fascial lining of its walls. It is ovoid in outline, its vertical diameter being the longest, and it is slightly constricted in the middle by the waist. In the median part posteriorly it is encroached upon by the bodies of the vertebræ and the psoas muscles, so that, in transverse section, the cavity is kidney-shaped (Figs. 126, 127, 130). In the region of the umbilicus, it is greatly reduced by the lumbar curve of the backbone; this is most marked when the body is recumbent, for the anterior wall then sinks inwards. Its upper part is the roomiest, and is to a large extent under shelter of the lower ribs and costal cartilages; it is therefore overlapped by a considerable portion of the thoracic cavity, for it reaches the level of the xiphi-sternal joint and the eighth thoracic spine in the median plane, and still higher on each side—almost to the nipples in front and the scapulæ behind.

Boundaries.—The boundaries of the cavity are as follows:—Its roof is the diaphragm, which separates it from the cavity of the thorax. Its floor is formed by the levatores ani, which separate it from the perineum. In front, behind, and at each side, it is bounded by muscles, tendons and aponeuroses; and these, as well as the diaphragm and the levatores ani, are lined with fascia. The fascia is the innermost layer of the walls of the cavity of the abdomen; it is separated from the peritoneum by the extraperitoneal tissue and the other contents of the cavity.

The walls of the abdomen are to some extent stiffened by

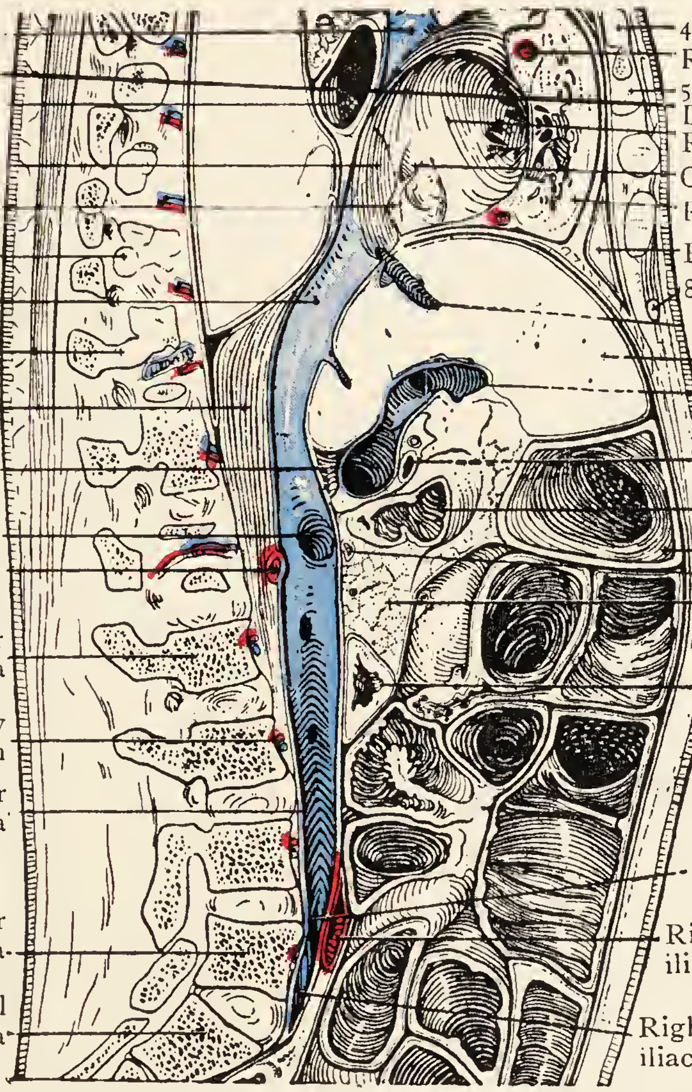


FIG. 121.—Sagittal Section of upper part of Abdomen and lower part of Thorax of a Young Man along the line of the Inferior Vena Cava.

(D-D. Plane of section shown in Fig. 55, p. 99.)

bones which provide both support and protection. The bony true pelvis encloses the lower part and, besides protecting its viscera, gives it the rigidity it requires as a base for the trunk resting on the lower limbs; and the ilia, owing to their great expansion behind and at the sides, give protection and support to the viscera in the false pelvis. In the upper part, the lumbar vertebræ and the lower thoracic vertebræ provide a column of support and a great measure of protection posteriorly. The lower ribs and costal cartilages also afford protection to a considerable extent behind, to a still greater extent at the sides, and to a much less extent in front. The exposed parts of the walls that are unsupported and unprotected by bones are a great lozenge-shaped area in front and a belt of variable width between the iliac crest and the costal margin on each side.

The absence of bony support from these parts is accounted for by the fact that they are the parts which require to be yielding, elastic and mobile. When the abdomen is opened by the ordinary dissecting methods and when diagrams of sections of the abdomen are examined, it appears as though its contents did not quite fill it (Fig. 125). This appearance is deceptive. The contents of the abdomen are so closely packed that there is no room for anything more (Fig. 121). It is necessary, therefore, that a great part of the abdominal walls should be free from the rigidity which bony support entails, in order to be capable of being stretched to give more room when food is taken, when gas distends the intestines and when the size of the upper part of the cavity is reduced by the descent of the diaphragm in respiration. This portion requires to be elastic in order to be able to recoil when distension of the hollow organs subsides and when the diaphragm ascends again; and it requires to be contractile also, in order that it may be able to compress the viscera in forced expiration and when their contents have to be expelled. The boneless parts of the front and sides of the abdomen have these requirements—extensibility, resilience and contractility.

Relation of Viscera to Abdominal Walls.—It has been indicated already that the viscera and certain other structures are situated in the extraperitoneal tissue. Almost all of them are related directly or indirectly to the back wall of the cavity—the only exceptions being the umbilical ligaments and small portions of the inferior epigastric vessels. Some of them are wholly behind the peritoneum, and are related to it only by their anterior surfaces—for example, the kidneys. Some of them bulge forwards and are covered with peritoneum on their sides as well as in front—for example, some parts of the large intestine. Some organs lose contact with the back wall—falling away from it and dragging off folds of peritoneum which suspend them and cover them almost completely—for example the small intestine (Fig. 126).

Extraperitoneal Tissue.—This is the layer of areolar tissue that forms a loose connexion between the peritoneum and the fascial lining of the abdomen, and extends into the folds of peritoneum loosely uniting their two layers. It contains a quantity of fat that varies in different bodies and in different parts of the same abdomen. It is absent at the roof; it is scanty at the anterior wall and at the sides; in a well-nourished body, it is abundant on the posterior wall, on the floor and in the folds of peritoneum.

Peritoneum.—The peritoneum is the smooth, moist, glistening membrane that lines the walls of the cavity of the abdomen, and is reflected from the walls to reach the viscera and cover a varying extent of their surfaces.

Arrangement of Peritoneum.—Like the other serous membranes, the peritoneum is divisible into a *parietal part* which lines the walls or parietes, and a *visceral part* which covers the viscera and forms the folds that connect some of them with the parietes. These two divisions of a serous membrane are parts of one continuous membrane which may be regarded as being originally a simple closed sac that lines the walls of a closed cavity. A viscus is placed between the sac and a part of the wall, and then is, so to speak, pushed or invaginated into the sac as the fist might be pushed into a collapsible rubber-ball ; the ball, thus doubled into itself, is converted into a cup of two layers, one inside the other, and the original space inside the ball is reduced to a mere chink, while the two layers are still continuous with each other at the rim of the cup.

As the developing cavity and sac increase in size, a viscus may be pushed so far into the invaginated sac that it loses contact with the wall of the cavity. The parts of the "visceral" layer that cover the sides of the viscus then come together behind it and form a " fold " that stretches from the viscus to the part of the wall from which it started. A fold of peritoneum therefore does not have the usual meaning of the word " fold." It is a double sheet of peritoneum connected with a viscus. At its visceral margin, its two layers are attached to the viscus by extraperitoneal tissue and then separate to become continuous with the peritoneum on the surfaces of the viscus. At the parietal margin, the two layers are attached to the wall in the same way, and then separate to become continuous with the parietal peritoneum on each side of the fold.

Such simple arrangements as those outlined are retained in the relation of the lung to the pleural membrane (Fig. 5, p. 17), and will be seen also when the small intestine and the part of the large intestine called the ascending colon are examined : the colon merely bulges into the peritoneal sac ; the small intestine is suspended by a fold (Fig. 126). But the arrangement and connexions of the original folds of peritoneum have been so modified during evolution and development by the profound changes which have taken place in the size, shape and position of abdominal organs and by the disappearance and the fusion of parts of some folds and the exuberant growth of others that in many places all semblance of simplicity is lost. Thus, some folds pass, not from an organ to the parietes, but from one organ to another, and one of these, called the *greater omentum*, is doubled so that it has four layers, and yet is so long and wide that it hangs down from the stomach, like an apron, concealing the intestines.

Different general names are given to these folds of peritoneum. Many of them are called *ligaments*; two of those connected with the stomach are called *omenta*; the one connected with the small intestine is called the *mesentery* (*enteron* means intestine); and *mesocolon* is the name given to two large folds connected with the large intestine.

Structure of Peritoneum.—The peritoneum is by far the largest of the serous membranes, and in common with the others—pleuræ and pericardium—it consists of a layer of elastic areolar tissue (of varying thickness) covered with a layer of simple squamous epithelium.

Peritoneal Cavity.—The peritoneal cavity is the space enclosed by the peritoneum, and, in contrast with the abdominal cavity, it is empty except for the film of lymph that keeps the surfaces moist; for the viscera are so closely packed together that at all points the space is reduced to the mere capillary interval that contains the lymph. But it can become capacious in abnormal circumstances:—(1) when air is let into it through a cut in the abdominal wall; (2) when lymph exudes in great quantity into it through the peritoneum in the condition called *ascites* (dropsy of the abdomen); or (3) when the contents of the alimentary canal escape into it through a ruptured stomach or intestine.

Students, failing to grasp (or forgetting) the distinction between the *abdominal cavity* and the *peritoneal cavity*, sometimes regard these terms as synonymous, and are at a loss to understand how a cavity can be full and empty at the same time. They may understand it better if a familiar object is taken as an example—a leather bag with a cotton lining. The leather represents the abdominal walls including the fascia;

the cotton is the peritoneum. If a hole is made in the leather and articles are pushed through it into the bag, between the leather and the cotton lining, till it can hold no more, the bag is then full, but, if its mouth is opened, its " peritoneal cavity " is seen to be empty.

In the male, the peritoneum is unbroken, and the peritoneal cavity is entirely closed. Not so in the female. On each side, the uterine tube, which conveys the ova from the ovary to the uterus, makes a breach in the peritoneum of the pelvis, and opens into the peritoneal cavity. Thus, in contrast to the condition in the male, the peritoneal cavity in the female is placed indirectly in communication with the exterior.

Divisions of Peritoneal Cavity.—Owing to the disappearance, fusion, shifting, shortening, or the redundant growth of different folds of peritoneum during development, the peritoneal cavity has become divided into two distinct parts—the cavities of the greater and lesser sacs.

The **greater sac** is the part opened into when the anterior wall of the abdomen is cut or removed. The **lesser sac** is not found until dissection is made ; it is situated behind a part of the liver called the caudate lobe, behind the lesser omentum, behind the stomach, and in the greater omentum. It is almost entirely shut off from the greater sac ; their cavities communicate with each other only through one short canal, called the *opening into the lesser sac*, which is barely wide enough to accommodate two fingers.

Contents of Abdomen.—These are :—

1. Abdominal part of alimentary canal
   - Terminal part of œsophagus.
   - Stomach.
   - Small intestine.
   - Large intestine.
2. Liver, with gall-bladder and ducts.
3. Pancreas.
4. Spleen.
5. Kidneys and ureters.
6. Suprarenal glands.
7. Lymph-glands and lymph-vessels.
8. Cisterna chyli and beginning of thoracic duct.
9. Abdominal aorta and its branches.
10. Inferior vena cava and its tributaries.
11. Lower parts of vena azygos and inferior vena hemiazygos.
12. Portal vein and its tributaries.
13. Lumbar plexuses of nerves.
14. Abdominal parts of sympathetic nervous system and of vagi.
15. Pelvic organs, which will be detailed later.

Preliminary Examination of Viscera.—Under the guidance of the following paragraphs, the dissectors will make a preliminary examination of the organs, noting their outstanding characters and their positions before they have been displaced by dissection.

With regard to position, they must not expect to find every organ in the exact position assigned to it in this account. The abdominal organs of different bodies vary very greatly in dimensions and shape. Some parts of the alimentary canal are very movable, but even those organs that are relatively fixed vary in position with the bodily habitus and associated variations in form of the abdomen as well as with differences in their own size and shape, and also with the degree of distension of the hollow organs at the time of death. In the same body, during life, they vary in position, size and shape with the advance of years; there are variations also during the course of a day, since the hollow organs are continually undergoing change with increase and diminution of their contents. And one notable difference results from a change in attitude: in the erect attitude, the diaphragm and the abdominal viscera are lower than they are in the recumbent attitude. The position and relations given are those most likely to be found in a body lying on its back, for that is the usual position of the body when the abdomen is examined either in the dead or in the living.

It should be stated, however, that radiologists recognise a greater range of variation and a lower average position in the living body than is usually found in the cadaver. Students must therefore take advantage of every opportunity presented to them of becoming familiar with the range of variation in the position of organs in the living body—both absolute and relative to the position of the body as a whole (Figs. 120, 122, 137, 138).

When the anterior wall of the abdomen is removed or is cut and turned aside, the only structures seen at once in every cadaver are:—the falciform ligament, the liver, the stomach and the greater omentum.

The *falciform ligament* has been noted already. A portion of the *liver* is seen in the uppermost part of the Λ-shaped interval between the right and left costal margins, and also protruding below the right costal margin (Fig. 120). A portion of the *stomach* is seen between the liver and the left costal margin. The *greater omentum* is the long, wide fold of peritoneum (often loaded with fat) that hangs down from the stomach, concealing the viscera below the stomach and liver (Fig. 128).

A few *coils of intestine*, however, are often seen at the margins of the omentum; and, usually, the lower end of the *gall-bladder* is seen peeping out from behind the lower edge of the liver. It may chance that the *urinary bladder* is full, and then its upper part will be seen above the pubic symphysis. In a pregnant woman, the *uterus* will be visible—reaching a height that varies with the period of gestation.

Pass the fingers upwards under the costal margin, first on one side and then on the other; press upwards and sidewards and forwards: in every direction the fingers meet the *diaphragm*.

Examine the *liver*. It is the bulky, reddish-brown organ that lies in the upper, right part of the abdomen; it is largely concealed by the ribs and the diaphragm, and the greater part of it is situated in the right hypochondrium; it is smooth and glistening owing to its coat of peritoneum. Trace the falciform ligament to the liver, and note that it is attached to the upper and anterior surfaces of the liver. This attachment is made use of to divide the liver into *right* and *left lobes*, of which the right is very much the larger. Pull the left lobe away from the diaphragm, and look for a fold of peritoneum which is then put on the stretch; it is called the *left triangular ligament* of the liver, and connects the left lobe with the diaphragm. Pass the fingers backwards over the top of the right lobe. They are intercepted by a layer of peritoneum, called the *upper layer of the coronary ligament*, which is reflected from the back of the right lobe on to the diaphragm. Run the finger towards the right along that layer; it comes to a free edge where the upper layer of the ligament is continuous with the *lower layer*; the edge (with the part of the two layers that immediately adjoin it) is the *right triangular ligament*. Pass the fingers upwards behind the right part of the right lobe and press backwards; the upper part of the *right kidney* is felt as a slight bulging; the fingers pressed upwards will meet the lower layer of the coronary ligament.

Pull up the liver as far as possible, and pull down the stomach. A fold of peritoneum called the *lesser omentum* is then seen ; it stretches between the liver and the stomach, and is hidden behind the left lobe of the liver in the natural position of parts. At its right or lower part, its two layers become continuous with each other to form a *free margin*, and, superiorly, they are attached to the lips of the *porta hepatis*. The porta is a wide, transverse cleft situated far back on the lower surface of the right lobe, and through it vessels, nerves and ducts enter and leave the liver. It cannot be seen at present, but its position can be gauged if the right part of the lesser omentum is traced up to the liver.

Now, examine the *gall-bladder*, which lies on the lower surface of the liver. When it is full, it is more or less pear-shaped. Its blunt, lower end is called its *fundus*, and it usually projects below the lower edge of the liver. The fundus is succeeded by the *body*, which extends obliquely backwards, upwards and medially, tapering to form the *neck* at its upper end. The neck lies at the margin of the lesser omentum near the right end of the porta hepatis, and is continued into the duct of the gall-bladder, which is called the *cystic duct* (*cystis* means a bladder). The fundus is clothed on all sides with closely adherent peritoneum ; but the body and neck lie between the liver and its peritoneum, and are covered therefore only on the lower surface and the sides.

Trace the free edge of the falciform ligament to the edge of the liver. The *round ligament* (or ligamentum teres) leaves the falciform ligament there, and runs to the left end of the porta in a fissure which separates the right and left lobes on the lower surface of the liver. The portion of the right lobe that lies between this *fissure for the ligamentum teres* and the gall-bladder is called the *quadrate lobe*.

Before leaving the liver, determine the level of its upper surface. Identify the ribs on the right side of the chest, and the xiphi-sternal joint in front. The upper surface of the liver is at the level of the joint and of the seventh rib in the mid-axillary line, and is only a little below the level of the nipple.

Turn now to the *stomach*. It lies in the upper left part of the abdomen. A large portion of it is hidden behind the liver and the diaphragm and is under shelter of the ribs, but the portion seen when the abdomen was opened is related to the anterior abdominal wall; the stomach is therefore easily reached through an incision made in that wall. Its surface is smooth and glossy owing to its peritoneal coat; and it is connected with other organs by folds of peritoneum. Run the fingers up over it to its uppermost part, which is full and rounded, and is called the *fundus*; note the position of the fundus relative to the nipple: its highest point is usually opposite the fifth rib directly below the nipple. Feel for the end of the *œsophagus*, which pierces the diaphragm and at once joins the stomach at the right side of the fundus. Draw a finger firmly to the right and downwards along the lower part of the stomach till, near the right edge of the lesser omentum, a thickening is felt in the stomach wall. That thickening marks the lower end of the stomach, which is called the *pylorus* and is continuous with the duodenum—*i.e.* the first part of the small intestine. The borders of the stomach extend from the pylorus to the entrance of the œsophagus. The *lesser curvature* is the right or upper border, and is concave. The *greater curvature* is very blunt, and is highly convex, especially at the fundus; its lower part, from which the greater omentum hangs, is usually called the lower border of the stomach. This border is very variable in position in the living body; it is often very low down in the abdomen when the stomach is full and the body is in the erect position (Figs. 136, 137).

Pull up the liver again. Note the *first part of the duodenum* passing from the pylorus backwards and upwards, and bending suddenly downwards to become the *second part*. While your partner holds the liver up, pull the pylorus and duodenum downwards to put the free margin of the lesser omentum on the stretch, and slip the left forefinger in behind that margin. The finger is now in the *opening into the lesser sac* of peritoneum, and is in relation posteriorly with the largest vein in the body, namely, the *inferior vena cava*, which is passing upwards to enter a deep, wide, vertical groove on the back of the liver. Grip the free margin of the lesser omentum between finger and thumb; certain structures are felt in it which will be dissected later: they are the *portal vein* and the *hepatic artery* (ascending to the porta hepatis) and the *bile-duct* (descending from the porta). Now, pass the finger a little farther to the left and then sharply upwards. The finger will slip into a narrow extension or recess of the lesser sac between the diaphragm and the back of the right lobe of the liver on the medial side of the inferior vena cava. The portion of the back of the liver felt here is called the *caudate lobe* (Figs. 125, 176); it is bounded on the left by a deep, narrow, vertical cleft which separates the right lobe from the left on the back of the liver. The cleft is called the *fissure for the ligamentum venosum*, because a slender cord of that name lies in it; but what the students are to take particular note of at this stage is that the upper part of the lesser omentum passes into the fissure to be attached to the bottom of it.

Now, find the *spleen*. It is a soft, pliable organ of variable size, but, on the average, about as big as a fist; it lies hidden behind the stomach in the left hypochondrium. Pass the hand backwards between the diaphragm and the upper part of the stomach and then downwards and medially behind the stomach. The spleen will be felt close to the back of the stomach. Its peritoneal coat clothes it almost completely, and therefore, if there have been no inflammatory adhesions between peritoneal surfaces, it is easily grasped in the hand. But it cannot be displaced far, for it is bound to other organs by two folds of peritoneum. One of these—the *gastro-splenic ligament*—passes from it to be attached to the stomach at or near the left part of the greater curvature. The other is called the *lieno-renal ligament* and connects the spleen with the front of the upper part of the left kidney. Identify the ribs at the back of the left half of the thorax, and gauge the position of the spleen relative to them. It is usually opposite the ninth, tenth and eleventh.

Pass the fingers behind the spleen, press backwards and feel the slight bulging caused by the upper part of the *left kidney*.

The *suprarenal gland* is a small organ placed on the medial part of the top of each kidney; but it cannot be found without dissection, for the right one is wedged in behind the right lobe of the liver, and the left one is behind the stomach and the lesser sac of peritoneum.

Pull the upper part of the stomach downwards and medially, and pass the finger upwards and downwards over the gastro-splenic ligament. Inferiorly, the ligament is continuous with the left border of the greater omentum. Superiorly, it is continuous with a fold of peritoneum called the *gastro-phrenic ligament* that passes to the diaphragm from the uppermost part of the greater curvature of the stomach.

Lift the greater omentum and throw it up over the costal margin. The *intestines* are now exposed. The part of the *large intestine* known as *the colon* runs round the small intestine like a frame, and can be distinguished from the small intestine at a glance, for the *appendices epiploicæ*—little pouches of peritoneum filled with fat—are attached to the surface of the colon (*epiploicus* = floating on the surface); further, the colon is puckered and the small intestine is smooth.

Examine the *large intestine* first. Its subdivisions are:—cæcum (with vermiform appendix), ascending colon, right flexure, transverse colon, left flexure, descending colon, pelvic colon, rectum and anal canal (Fig. 162).

The *transverse colon* sweeps across the abdomen from the lower surface of the right lobe of the liver to the lower part of the spleen, behind the greater omentum, usually a little above the level of the umbilicus and near the lower border of the stomach (Fig. 120). It is attached to the back of the greater omentum, and is now seen thrown up with it.

It has been mentioned already that the greater omentum is a fold doubled on itself. It has therefore four layers. The posterior two layers are continuous with the anterior two at the right and left margins and at the lower border. From the lower border, the posterior layers ascend to the transverse colon (Fig. 125), separate to enclose it and then proceed upwards and backwards under another name—the *transverse mesocolon.* The transverse mesocolon is now seen extending to the posterior abdominal wall, where it is attached to the lower border of the *body of the pancreas.* Its two layers separate there finally—the one passing upwards over the structures on the posterior wall of the abdomen, the other downwards.

The body of the pancreas is about the breadth of two fingers and about four or five inches long. It lies obliquely across the back wall behind the stomach; a small part of it is seen at the root of the transverse mesocolon, but dissection is required to expose it fully.

Return to the transverse colon, and note that the puckering appears to be due to the tension of longitudinal muscular bands on the surface of the colon. There are three of these bands; they are placed at nearly equal distances from each other, and are called *tæniæ coli* (*tænia* means a band or ribbon). Trace the transverse colon towards the right. It gradually approaches the posterior wall, where it lies across the *head of the pancreas* and the second part of the duodenum; and, on the front of

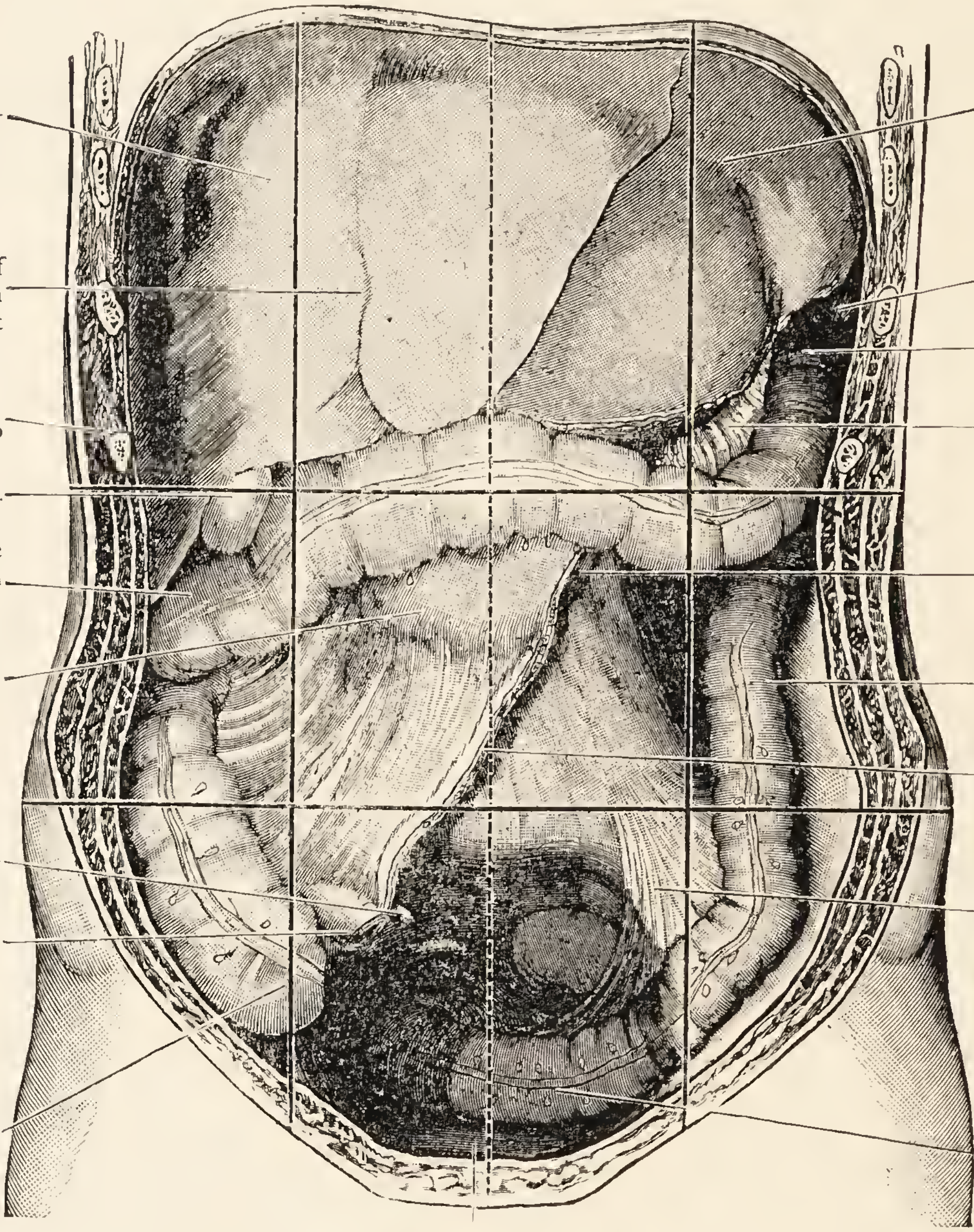


FIG. 122.—Abdominal Viscera after the removal of Jejunum and Ileum. (Birmingham.) The Liver and the Cæcum are lower in the abdomen than is usual in formalin-hardened bodies; they are, however, often found in this position in the living subject. Cf. Figs. 140 and 162.

the lower part of the right kidney, it makes a right-angled bend and becomes continuous with the ascending colon. The bend is the *right flexure* of the colon; it lies on the right kidney, closely related to the right lobe of the liver, which overlaps it.

Follow the *ascending colon* downwards. It has no mesocolon, for it lies on the posterior wall of the abdomen and is covered with peritoneum only on its front and sides; in the right iliac fossa it is continuous with the cæcum. Note that we have been tracing the colon in the reverse direction. The *cæcum* (as the name implies) is the blind commencement of the large intestine. Look on the medial side of the large intestine at this point. It is joined there by the end of the small intestine, and the entrance of the small intestine into the large marks the junction of the cæcum and ascending colon. Lift up the cæcum and look for the *vermiform appendix*, which is a worm-like structure, as its name suggests, and is about four inches long. It springs from the back of the cæcum, and is enclosed in one of the two free edges of a small fold of peritoneum called its mesentery. If the appendix is not found at once, trace the anterior tænia of the ascending colon downwards, and it will lead you to the appendix, for the three tæniæ begin at its root.

Come back to the transverse colon, and trace it towards the left. It approaches the back wall, crosses the left kidney immediately below the pancreas, and ends at the lateral border of the kidney by making a sharp bend and becoming continuous with the descending colon. The bend is the *left flexure* of the colon. The spleen rests on it and on a small shelf of peritoneum, called the *phrenico-colic ligament*, which is pinched up between the flexure and the diaphragm. Identify the lower ribs of the left side, and note the level of the flexure and the ligament: they are usually opposite the eleventh rib in the mid-axillary line.

Follow the *descending colon* downwards. Like the ascending colon, it lies on the back wall and is covered on its sides and front with peritoneum. Usually, it is much narrower than the ascending colon, and may, at times, be even narrower than the small intestine. It curves downwards along the margin of the left kidney, crosses the iliac crest, descends through the left iliac fossa to the medial side of the anterior superior iliac spine, and then runs medially, near the inguinal ligament, to end at the pelvic brim by becoming the pelvic colon.

The *pelvic colon* lies in the pelvis, and makes one or more loops according to its length. It is movable, and most of it can be pulled out of the pelvis, for, like the transverse colon, it is slung by a *mesocolon*, which has a Λ-shaped attachment to the brim and back wall of the pelvis. The pelvic colon ends at the middle piece of the sacrum by becoming the rectum.

The *rectum* descends over the pelvic surface of the sacrum and coccyx, curved in conformity with them ; beyond the coccyx, it becomes the anal canal, which pierces the pelvic floor and ends in the perineum. The upper part of the rectum bulges the peritoneum forwards from the sacrum, and it can therefore be seen and grasped ; but the lower part is hidden below the peritoneum. The position of the *anal canal* was ascertained when the perineum was dissected.

The *small intestine* is over 20 feet long, and is divided into three parts called the duodenum, the jejunum and the ileum.

The *duodenum* is the first ten inches. It begins at the pylorus, and is curved like the letter C round the head of the pancreas. It is divisible therefore into four parts. The *first part* has been seen already passing backwards, upwards and towards the right from the pylorus ; when the organs are undisturbed, it ends at the neck of the gall-bladder. The *second part* descends over the back wall overlapping the medial part of the right kidney, and ends at the level of the third lumbar vertebra. The *third part* passes to the left across the inferior vena cava and the aorta immediately above the level of the umbilicus. The *fourth part* is short, and passes obliquely upwards at the left side of the aorta to end at the level of the second vertebra by bending sharply forwards to join the jejunum. The bend is called the *duodeno-jejunal flexure* ; it lies immediately below the pancreas and behind the transverse mesocolon.

The *jejunum* and *ileum* together are twenty feet long. There is no sharp boundary line between them, but it is usual to reckon the first two-fifths as jejunum and the rest as ileum. They differ from the duodenum in that they are suspended from the back wall by the fold of peritoneum called *the* mesentery, and their coils are therefore movable. The position of the coils is consequently variable, but the jejunum tends to be above and to the left, and the ileum below and to the right, and its lowest coils are in the pelvis. Seize any of the upper coils ; follow the gut upwards to the flexure ; and identify the fourth and third parts of the duodenum.

Pull all the coils of the jejunum and ileum over to the left, and examine *the mesentery*. Trace the attachment of its root. The root begins at the duodeno-jejunal flexure, crosses the duodenum at the junction of its third and fourth parts, and then runs obliquely to the right iliac fossa to end at the entrance of the ileum into the large intestine. Note that the last part of the ileum ascends out of the pelvis to join the large intestine. Press the finger-tip along the right side of the mesentery at its root. If the mesentery is not overloaded with fat and if the arteries are well injected, a large artery will be felt. It is called the *superior mesenteric artery* ; it runs most of its course between the layers of the mesentery at its root, and sends numerous branches to the intestines ; its vein lies along its right side.

Trace the mesentery towards the gut, and note the goffering which it undergoes to accommodate itself to the coils of the gut (Fig. 152). Take a coil of the upper part of the jejunum and one of the lower part of the ileum. Compare the appearance of the mesentery near the gut at those two parts, and note this difference. At the ileum the fat is abundant in the mesentery and even overlaps the gut ; and it conceals the vessels. At the jejunum the fat is scanty ; the vessels are seen shining through the peritoneum, with fairly clear spaces between them like window-panes. This difference is of great practical importance. If a loop of intestine is pulled out through an incision in the living abdomen, the operator must recognise which part of the intestine it belongs to. No matter whether the incision is high or low, it may be small intestine or transverse colon or pelvic colon. If there are no appendices epiploicæ present, then it is small intestine, but may be either jejunum or ileum ; if " windows " are seen in the mesentery, it is part of the jejunum. If appendices epiploicæ are seen the coil may be either transverse colon or pelvic colon, and they are distinguished from each other by the fact that the transverse colon is connected with two folds of peritoneum, and the pelvic colon with only one.

Before leaving the small intestine, trace the ileum upwards from its lower end for a few feet and look for the **diverticulum ilei**—which, however, is present in only two per cent. of bodies. It is a short diverticulum—one or two inches long—pouched out from the ileum about three feet from its lower end, and is of the same diameter as the ileum. Its end is usually free and rounded ; but, as it is a persistent part of the vitello-intestinal duct of the embryo, its end may be attached to the umbilicus. When that is the case, it is a potential danger, for a loop of intestine may twist round it and become obstructed.

Pull the pelvic colon and the coils of ileum out of the pelvis and look for the *urinary bladder*. It lies in the anterior part of the pelvis. If it happens to be fairly full, it will be seen bulging upwards above the pubis. If it is empty, it is inconspicuous, for the peritoneum covers only its upper surface; it is hidden therefore in the fat and fascia below the peritoneum, and is felt as a soft yielding structure behind the pubic bones. If the subject is fairly free from fat, the *ureter* will be seen shining through the peritoneum as it descends in the pelvis, far back on the side wall, and may be seen curving forwards towards the bladder (Fig. 206).

If the subject is male, the *vas deferens* will be seen shining through the peritoneum, and can be traced from the deep inguinal ring as far as the posterior angle of the bladder, where it dips down into the fascia between the bladder and the rectum. As the peritoneum passes from the bladder to the rectum, it forms the floor of a shallow depression called the *recto-vesical pouch*. Pass the hand into the pouch, and feel for its lateral boundaries; they are a pair of blunt ridges of peritoneum called the *sacro-genital folds*; each begins a little lateral to the rectum and curves forwards to the point where the vas deferens disappears at the bladder; it is usually indistinct, and is raised up by an ill-defined thickening of the fascia of the pelvis.

If the subject is female, the *uterus* is seen rising prominently between the bladder and the rectum, and inclining forwards to overhang the bladder. Grasp the uterus; pull it backwards and towards one side. A wide fold of peritoneum is seen stretching from the other side of the uterus to the side wall of the pelvis; and it receives the appropriate name of the *broad ligament of the uterus*. Look at its upper surface near the side wall of the pelvis. The structure found attached to it there is the *ovary*. The two layers of the ligament are continuous with each other anteriorly, making a free edge. Examine that edge. It contains a slender tube, called the *uterine tube*, which runs laterally from the uterus, and opens into the peritoneal cavity near the ovary. Examine the end of the tube; it widens out and splits into a number of diverging processes called *fimbriæ*.

The *round ligament of the uterus*, which was seen when the inguinal canal was dissected, may now be seen shining through the peritoneum as it runs from the deep inguinal ring to enter the broad ligament. As it runs in the broad ligament towards the uterus, it usually raises up a sharp ridge on the lower surface of the broad ligament.

Trace the peritoneum both forwards and backwards from the uterus. As it passes from the front of the uterus to the bladder, it forms the floor of a shallow recess called the *utero-vesical pouch*. The peritoneum on the back of the uterus dips down to cover a small part of the back of the vagina (a very important fact), and then passes backwards to the rectum forming the floor of a depression called the *recto-uterine* or *recto-vaginal pouch*. Each side boundary of the pouch is an indistinct ridge of peritoneum raised up by an ill-defined thickening of the pelvic fascia. The ridge is called the *recto-uterine fold*. It begins near the side of the rectum and curves forwards to the neck or lower part of the uterus.

Certain small recesses of the peritoneum in the abdomen proper should now be looked for—namely, the para-duodenal recess, the superior and inferior ileo-cæcal recesses, the retro-cæcal recess, and the recess of the pelvic mesocolon. They are of surgical importance, for the kind of hernia called *internal* or *retroperitoneal hernia* may take place in one of them by a knuckle of gut being forced into it.

The **recess of the pelvic mesocolon** is not always present. Lift up the pelvic mesocolon and run the finger-tip along the medial side of the lateral limb of its Λ-shaped attachment. If the recess is present, it may be large enough for the finger-tip to slip into it, as into a thimble, near the apex of the Λ. The back of the recess lies on or near the ureter as it begins to descend into the pelvis near that point.

Look for the ileo-cæcal recesses at the end of the ileum. They are almost always present. The **superior ileo-cæcal recess** is a chink between the end of the ileum and the *vascular fold of the cæcum* (ileo-colic fold), which is a small triangular fold of peritoneum that usually lies in front of the end of the ileum and contains one of the arteries of supply to the cæcum; the fold is attached to the mesentery and to the ascending colon and cæcum at their junction, and its medial margin is a free edge. The **inferior ileo-cæcal recess** is larger. It is below the end of the ileum, in front of the mesentery of the vermiform appendix, and is bounded anteriorly by the ileo-cæcal fold. The **ileo-cæcal fold** is usually a well-defined, triangular fold that fits into the angle between the ileum and the cæcum and contains some fat but no visible blood-vessels. It is attached to the ileum and either to the cæcum or to the mesentery of the vermiform appendix; its medial or lower margin is free and is usually very uneven.

Lift up the cæcum. Occasionally two folds of peritoneum

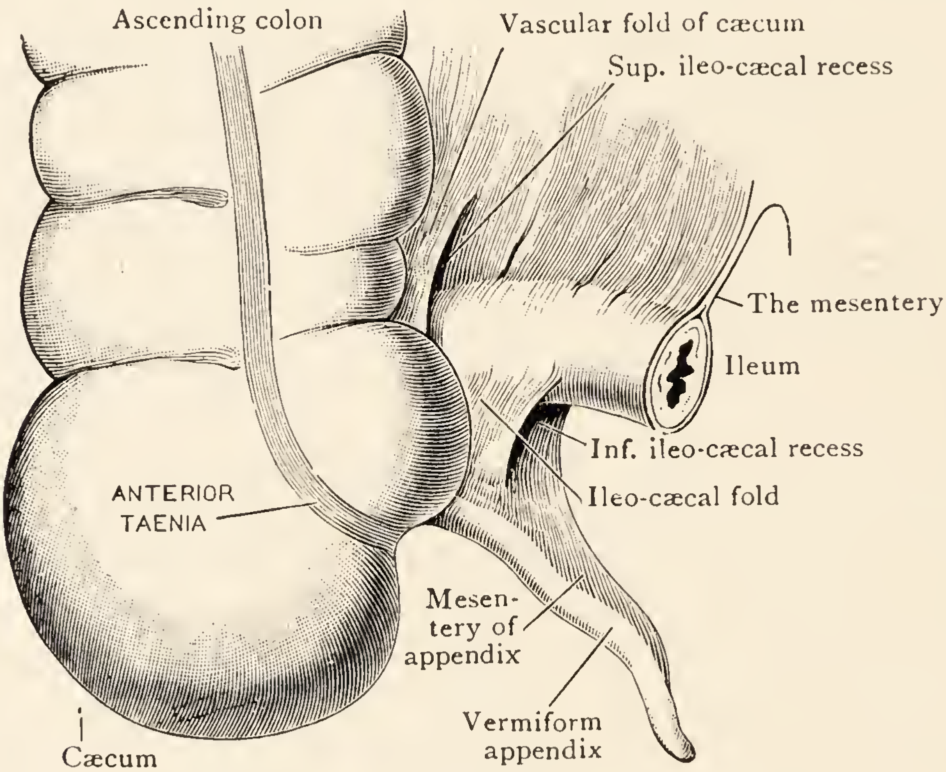


FIG. 123.—Ileo-Cæcal Region and Recesses.

are pinched up between its margins and the floor of the iliac fossa forming the side boundaries of a wide **retrocæcal recess**, which may extend upwards far enough to be retrocolic also. If the recess is present, the vermiform appendix will probably be found coiled up inside it.

Look for the **para-duodenal recess** at the left side of the fourth part of the duodenum. The recess is seldom present, for it is not formed unless a slightly aberrant course is taken by a vein called the inferior mesenteric. This vein usually runs a fairly straight course upwards on the posterior wall of the abdomen to pass behind the duodeno-jejunal flexure. But sometimes, as it approaches the flexure, it first inclines laterally and then curves sharply medially towards the flexure, raising up a small, arched fold of peritoneum whose margin looks medially and downwards. The recess is the little pocket behind the fold, and if a hernia forms in it, the vein, lying in the edge of the fold, must be avoided in the operation to release the hernia.

Other recesses—small and unimportant—may be found behind the fourth part of the duodenum or at its left side.

Greater Sac of Peritoneum.—The dissectors should now explore this great compartment of the peritoneal cavity. It extends across the whole breadth of the abdomen, and from the diaphragm to the pelvic floor. It is divided into an antero-superior part and a postero-inferior part by the stomach, the greater omentum and the transverse colon and mesocolon; but the division is incomplete, for the two parts are continuous with each other round the margins of the greater omentum (Figs. 125, 126).

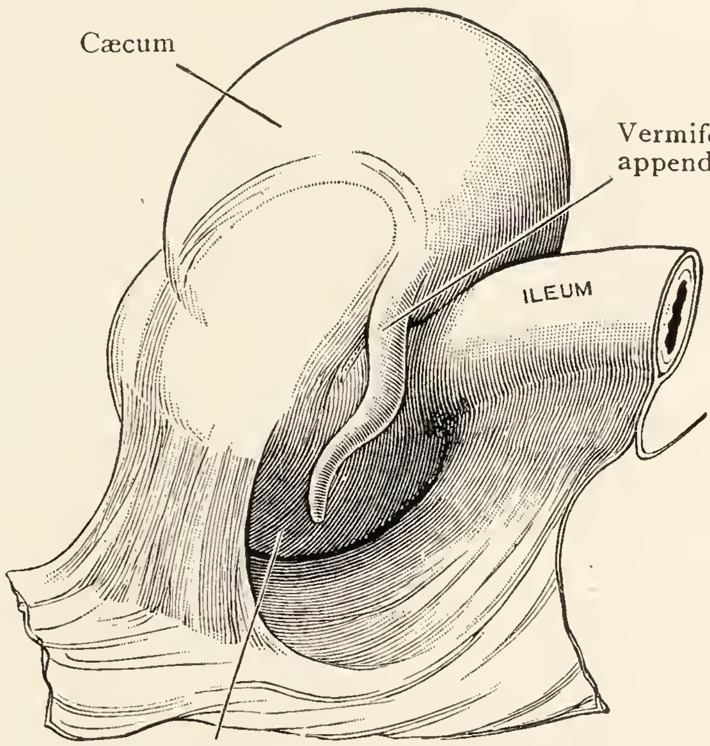


Fig. 124.—Ileo-Cæcal Region from below. The Cæcum has been turned up to show the Retro-cæcal Recess. Note the position of the Appendix.

The upper part of the *antero-superior part* is divided into right and left portions by the falciform ligament. Pass the hand backwards under the diaphragm at each side of the ligament, and note again that progress is barred by the coronary ligament, the left triangular ligament and the gastro-phrenic ligament. But, on each side, the space extends to the posterior wall of the abdomen, and forms a deep, longitudinal groove (Figs. 127, 130) in which liquids may collect when the body is recumbent.

The diaphragm and the abdominal muscles form the lateral boundary of each groove and the diaphragm separates its upper part from the pleura. The right groove is bounded medially by the right kidney and the ascending colon ; the

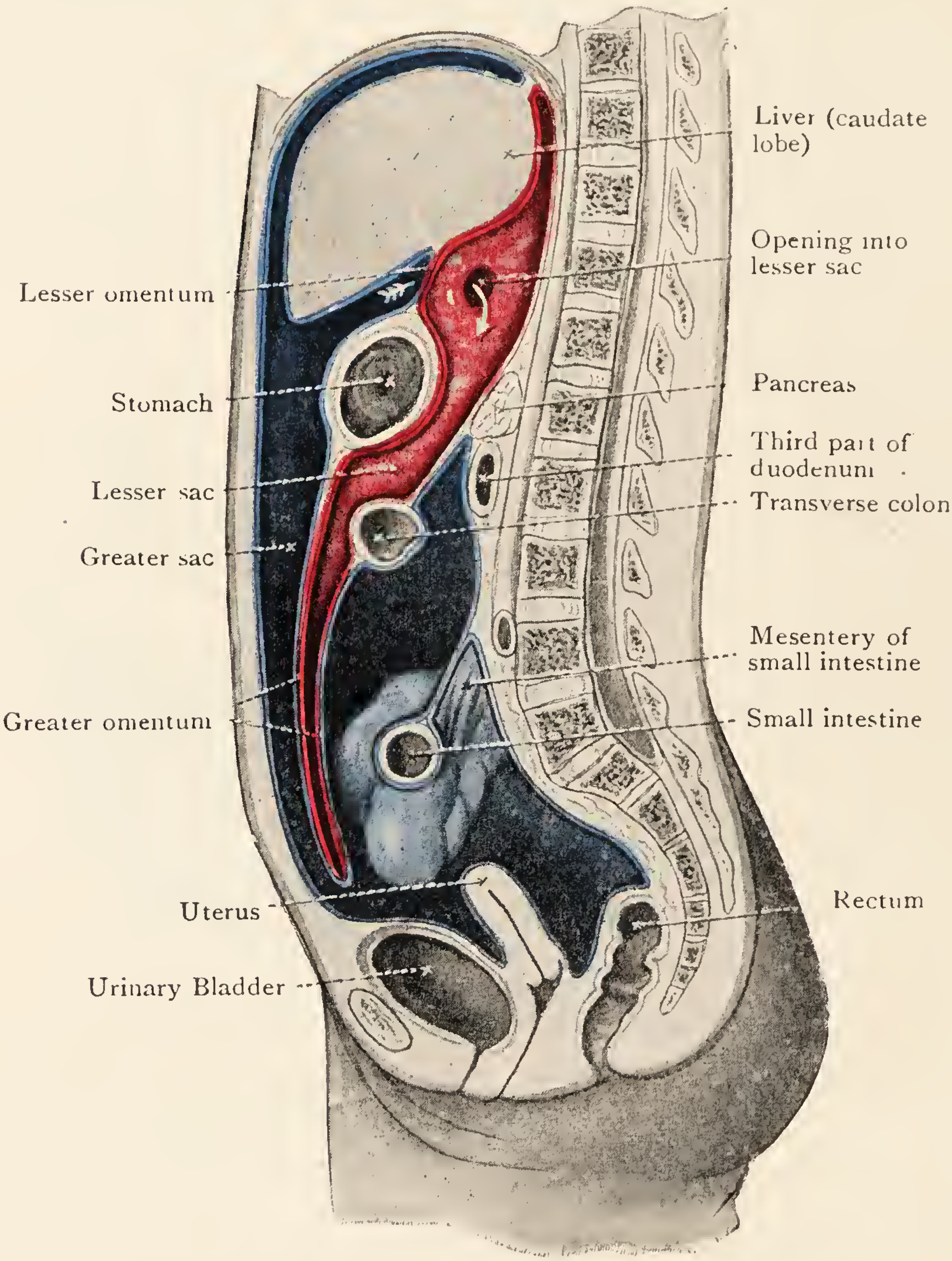


FIG. 125.—Diagrammatic Median Section of Abdomen (female) to show the Abdomino-Pelvic Cavity and the arrangement of the Peritoneum in vertical tracing. The peritoneal cavity is represented as distended; the Greater Sac is coloured blue, the Lesser Sac red ; the arrow passes from the greater sac into the lesser.

left groove by the left kidney and the lieno-renal ligament and by the descending colon.

Pass the hand from above downwards along each groove. On the left side, the hand is intercepted by the phrenico-colic ligament, which divides the groove into upper and lower portions. The right groove may be divided by one or more ridges of peritoneum pinched up at the lateral side of the ascending colon. These gutters and their subdivisions are of importance because they tend to localise abnormal collections of liquid ; and it should be noted that, in the recumbent

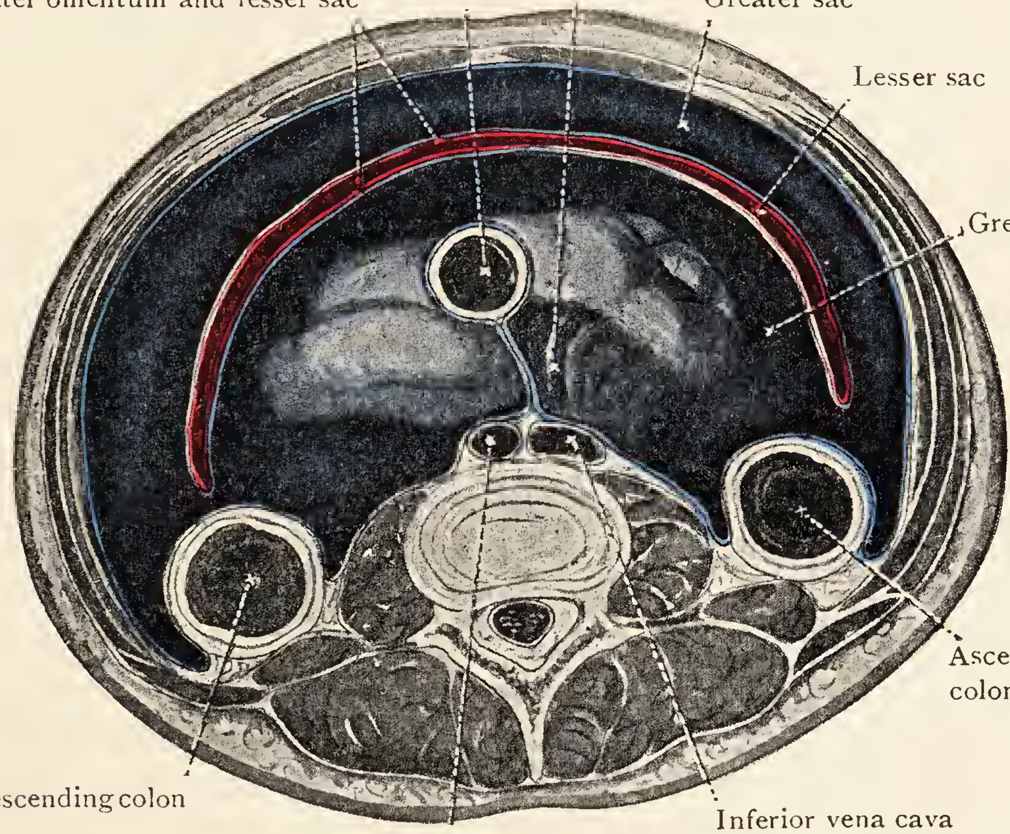


FIG. 126.—Transverse Section of Abdomen through the fourth lumbar vertebra, to show the arrangement of the Peritoneum.

position, such liquid will gravitate upwards, for the deepest part of each groove is at the upper part of the kidney opposite the last intercostal space.

The *postero-inferior part* of the greater sac is limited superiorly by the attachment of the transverse mesocolon to the pancreas (Fig. 125) ; and a great part of it is incompletely divided into right and left portions by the small intestine and its mesentery. The posterior walls of these subdivisions slope into grooves at the medial sides of the ascending and descending colon ; the right one is separated from the pelvis by the attachment of the mesentery, but the left one passes uninterruptedly into the pelvis.

Before proceeding to explore the lesser sac, the dissectors should examine the connexions of some of the peritoneal folds that they first met with.

Falciform Ligament of Liver.—This is a fairly wide fold of peritoneum that lies obliquely between the liver and the anterior wall of the abdomen, the "right" surface in close contact with the abdominal wall, and the "left" with the liver. It derives its name from the fact that it has a sickle-shaped outline when it is artificially put upon the stretch. (*Falx* means a sickle.) It has, however, three borders. One border is attached to the upper and anterior surfaces of the liver between the right and left lobes, some distance to the right of the median plane. Another border is attached to the diaphragm and to the anterior abdominal wall down to the umbilicus ; the upper part of this attachment may be a little to the right of the median plane, or it may retain its original median position, and then, if an exactly median incision were made through the abdominal wall, the knife would pass in between the two layers of the ligament. The third border is a free edge where the two layers of the ligament are continuous with each other and enclose the round ligament of the liver ; this border extends from the umbilicus to the edge of the liver at the anterior end of the fissure for the round ligament.

Round Ligament of Liver.—The round ligament or ligamentum teres of the liver is a slender cord made of fibrous tissue mixed with non-striped muscle, and is the obliterated remains of the *umbilical vein*, which carried pure blood from the placenta to the fœtus. The ligament runs in the free edge of the falciform ligament from the umbilicus to the liver, and then runs in its fissure to the left end of the porta hepatis, where it joins the left branch of the portal vein.

Left Triangular Ligament of Liver.—This small fold of peritoneum is put upon the stretch and brought into view when the left lobe of the liver is pulled away from the diaphragm. One border is attached to the back of the upper surface of the left lobe ; another is attached to the central tendon of the diaphragm a little in front of the œsophagus ; the third border is a free edge, directed towards the left, where the two layers of the ligament are continuous with each other.

Greater Omentum.—The greater omentum (the "caul") is the largest of the peritoneal folds, and hangs down from the stomach, separating the intestines from the anterior wall of the abdomen. In a well-nourished body, it is loaded with fat, and usually extends to the pubis and to the sides of the abdomen. Sometimes, however, it is less extensive, and coils of intestines may be seen at its margins; and, in a thin subject, it may be devoid of fat and resemble a thick gauze veil, or may be so shrunken or so folded and displaced by pathological adhesions that it conceals the intestines very incompletely. Slender arteries may be seen in it, if the injection has run well (Fig. 128), and some relatively large veins—seen better if the fat is scanty.

As mentioned already, the greater omentum is a double fold of peritoneum, and possesses therefore four layers—two anterior and two posterior, or first, second, third and fourth from before backwards. The anterior two layers are attached to the lower border of the stomach and to the first half-inch of the duodenum, where they are continuous with the peritoneum on the front and back of the stomach and duodenum. From this attachment, they descend to the lower part of the abdomen proper and then bend sharply backwards to become the posterior two layers. The posterior two layers ascend to be attached to the lower margin of the transverse colon, where they are continuous with the layers on the front and back of the transverse colon; and these, in turn, are continuous with the two layers of the transverse mesocolon (Fig. 125). Both the omentum and the mesocolon are attached to the colon much nearer its front than its back, and it therefore bulges backwards from them.

The first and second layers are continuous respectively with the fourth and third layers at the right and left margins of the omentum as well as at the lower border; and the lower part of the cavity of the lesser sac is enclosed between the second and third layers. The fact that there are four layers in the greater omentum can seldom be demonstrated except where they separate at their attachments to the stomach and transverse colon. The anterior two layers are united to each other by extraperitoneal tissue, and so are the posterior two; further, though the second and third layers are originally separated by the cavity of the lesser sac and may remain so throughout life, yet there is a tendency for them to fuse together partially or wholly, obliterating the cavity of the sac, till the lower part of the omentum, or even the whole of it, appears to be a single, thick layer of fatty areolar tissue enclosed in peritoneum.

At the colic attachment, small branches pass downwards between the posterior two layers from an artery called the middle colic, which supplies the transverse colon; and they are accompanied by veins. Near the gastric attachment, an arterial arch and a venous arch lie between the anterior two layers; they are formed by anastomosing vessels called the right and left gastro-epiploic, and from them branches pass up to the stomach and down into the omentum. (*Epiploön* is the Greek equivalent of the Latin *omentum*.)

The dissectors should now break through the anterior two layers of the greater omentum below the gastro-epiploic vessels, pass a hand into the lesser sac, explore its extent, examine its boundaries and confirm the statements made in the following paragraphs as far as the condition of the abdomen under dissection will permit. They may find, that a certain amount of adhesion has taken place between adjoining peritoneal surfaces, making the verification of some of the points difficult or impossible. They should also study Figs. 125, 126, 127, 130, in which the peritoneum is shown diagrammatically in section. In these figures, and also in the cadaver, they should trace the continuity of the different parts of the peritoneum in vertical and transverse section, noting that the peritoneum of the two sacs is in continuity only at the opening into the lesser sac.

Lesser Sac of Peritoneum (Omental Bursa).—It has been mentioned already that the cavity of the lesser sac is behind the caudate lobe of the liver, the lesser omentum and the stomach, and in the greater omentum. The *anterior wall* is formed therefore of:—(1) the peritoneum that clothes the caudate lobe; (2) the posterior layer of the lesser omentum; (3) the peritoneum on the back of the stomach; and (4) the second layer of the greater omentum. The *posterior wall* is formed of:—(1) the third layer of the greater omentum; (2) the peritoneum on the front of the transverse colon; (3) the anterior layer of the transverse mesocolon; and (4) the peritoneum that covers the structures on the posterior wall of the abdomen above the transverse mesocolon. The names and relative position of these structures are given under the relations of the stomach (p. 295) and of the lesser omentum (p. 275).

The lower part of the cavity is bounded *below*, and on the *right* and the *left*, by the continuity of the second and third layers of the greater omentum at its margins.

The upper part is bounded on the *left* by the lieno-renal and gastro-splenic ligaments. *Superiorly*, from left to right, its boundaries are:—(1) the gastro-phrenic ligament; (2) the reflexion of the peritoneum from the diaphragm on to the back of the stomach; (3) the attachment of the uppermost part of the lesser omentum to the diaphragm at the right side of the œsophagus; and (4) the reflexion of

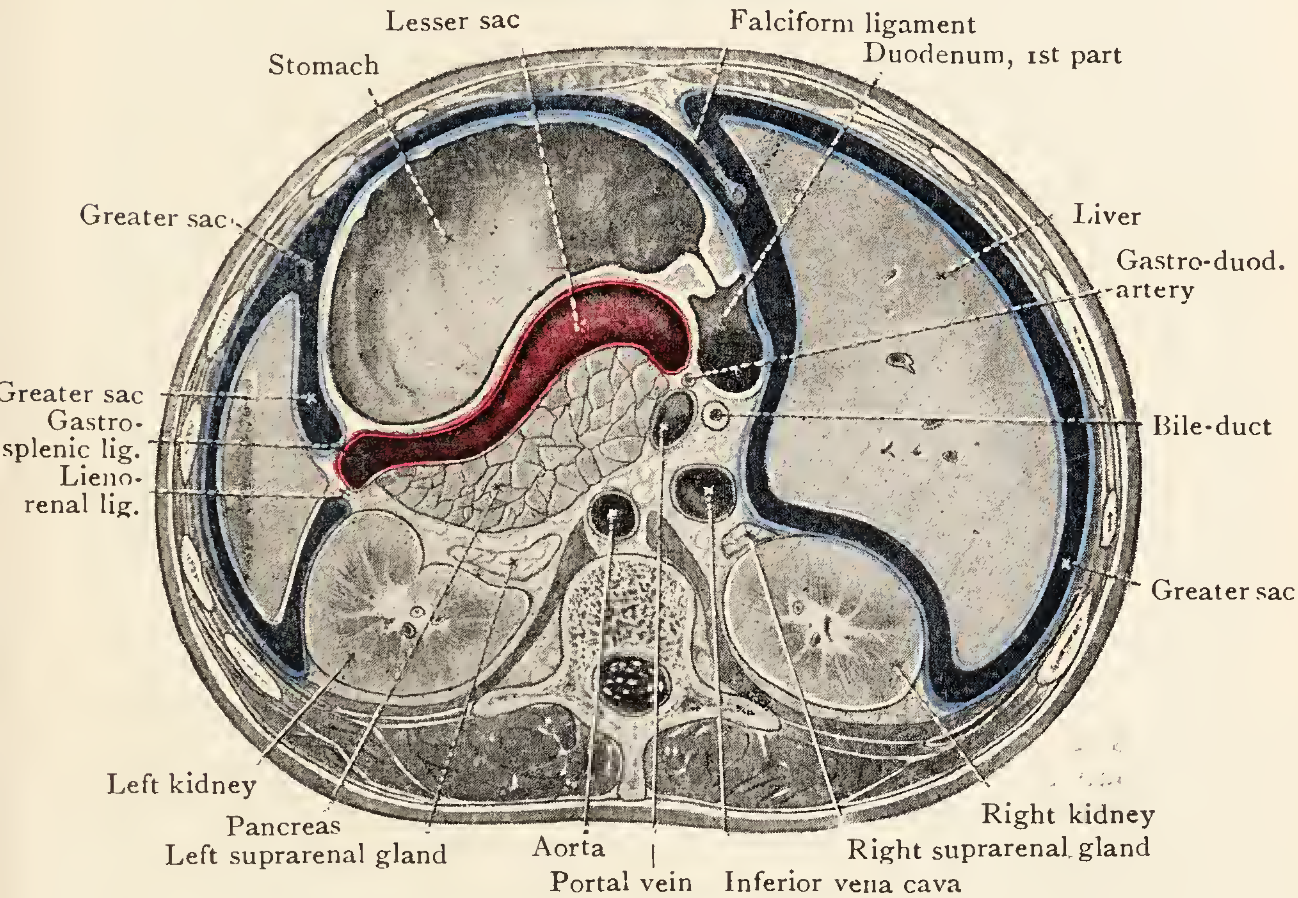


FIG. 127.—Transverse Section of Abdomen to show the arrangement of the Peritoneum immediately below the Opening into the Lesser Sac.

the peritoneum from the diaphragm on to the upper end of the caudate lobe of the liver. The *right* boundary of the upper part is interrupted by the opening into the lesser sac out of the greater sac. Between that opening and the right margin of the greater omentum, the boundary is formed by the peritoneum reflected from the back of the first part of the duodenum on to the front of the neck of the pancreas (Fig. 127). Above the opening, it is formed by the peritoneum reflected from the diaphragm on to the right margin of the caudate lobe.

The portion of the lesser sac situated in this region is a small recess between the diaphragm and the caudate lobe; the recess is bounded on the right and above by the peritoneum reflected from the diaphragm on to the right and upper margins of the caudate lobe, and on the left by the diaphragmatic attachment of the lesser omentum and the peritoneum reflected from the diaphragm on to the back of the stomach. When the body is recumbent, this recess is the deepest part of the lesser sac, and abnormal liquids in the sac gravitate into it.

Opening into Lesser Sac (Foramen Epiploicum).—The opening into the lesser sac is a short, transverse canal whose walls are in apposition with each other till artificially separated. It is situated behind the free margin of the lesser omentum and is bounded by the peritoneum that clothes the following structures :—*anteriorly*, the portal vein ; *inferiorly*, the first part of the duodenum and the portal vein as it curves forwards from behind the duodenum to enter the lesser omentum ; *posteriorly*, the inferior vena cava ; *superiorly*, the caudate process of the liver—*i.e.* a ridge of liver substance which separates the portal vein (in the porta) from the inferior vena cava (on the back of the liver), and connects the lower end of the caudate lobe with the rest of the right lobe of the liver.

The dissectors will now study the lesser omentum.

Dissection.—**If the liver is pliable, lift the left lobe upwards as far as possible to expose the lesser omentum, and fasten the lobe to the ribs with hooks or stitches. If the liver has been hardened, remove nearly the whole of the left lobe by dividing the left triangular ligament and then cutting through the lobe immediately to the left of the falciform ligament and the fissures for the ligamenta teres and venosum. Preserve the portion removed in order to re-attach it when necessary.**

FIG. 128.—The greater part of the left lobe of the liver has been removed and the remainder of the liver has been displaced upwards and to the right. The pyloric part of the stomach has been displaced downwards in order that the gastro-duodenal artery and more of the bile-duct may be seen.

Parts of the anterior layers of the omenta have been removed in order that the vessels in them might be displayed.

1. Falciform ligament.
2. Round ligament of liver.
3. Left hepatic artery.
4. Left hepatic duct.
5. Common hepatic duct.
6. Cystic artery.
7. Fundus of gall-bladder.
8. Cystic duct.
9. Bile-duct.
10. Gastro-duodenal artery.
11. Duodenum, second part.
12. Right gastro-epiploic vessels.
13. Section of left lobe of liver.
14. Lower part of caudate lobe, seen through lesser omentum.
15. Left gastric artery.
16. Right hepatic artery.
17. Portal vein.
18. Hepatic artery.
19. Lesser omentum.
20. Right gastric vessels.
21. Left gastro-epiploic artery.
22. Stomach.
23. Greater omentum.

PLATE XIII

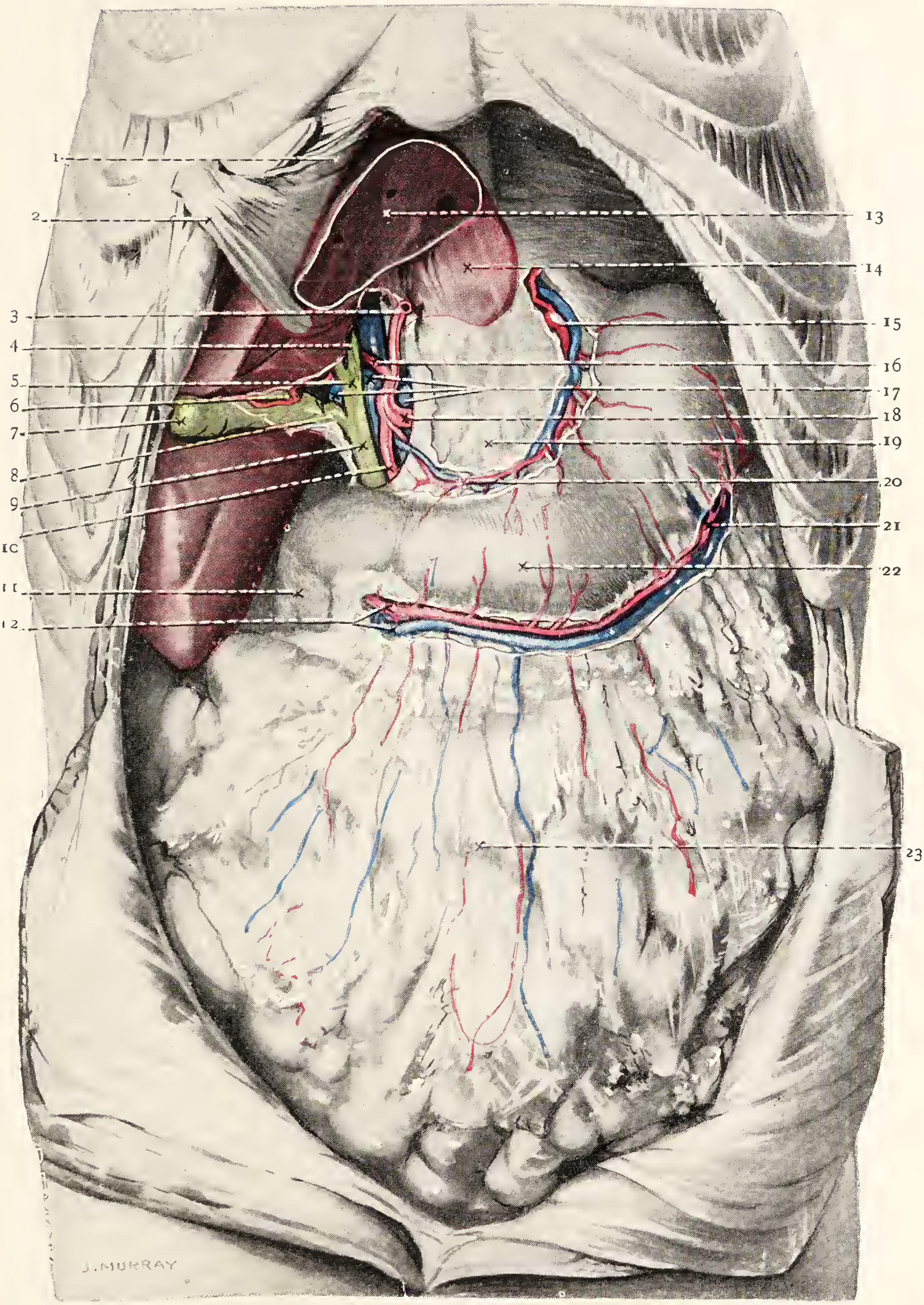


FIG. 128.—View of Interior of Abdomen after dissection to display Lesser Omentum and structures in relation to it

Compare with Figs. 129, 163 and 172.

[*Facing p. 272*

FIG. 129.—Dissection to display the Posterior Wall of the Lesser Sac of Peritoneum and some of its relations.

Compare with Figs. 128, 163 and 172.

[*Facing p.* 273

Lesser Omentum.—This fold of peritoneum has been partially examined already (p. 254); it was noted then that it was concealed behind the left lobe of the liver and was connected chiefly with the liver and the stomach. The lesser omentum does not support the stomach; indeed, it is sometimes so wide and slack that it can be pulled down as a double fold over the stomach; and its central part is often so thin that it appears as a filmy veil, and may even be fenestrated.

Pass the finger along its borders and examine its attachments more precisely.

Attachments.—The lesser omentum is attached :—*below and on the left*, to the first inch of the duodenum and to the lesser curvature of the stomach; *superiorly*, to the diaphragm for about half an inch immediately to the right of and above the œsophagus; *superiorly and on the right*, to the bottom of the fissure for the ligamentum venosum and to the lips of the porta hepatis. At its various attachments, its two layers are continuous (1) with the peritoneum on the front and the back of the duodenum and stomach, (2) with the peritoneum on the diaphragm, and (3) with the peritoneum that lines the two walls of the fissure, and the peritoneum on the liver near the

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FIG. 129.—The greater part of the left lobe of the liver has been removed and the remainder of the liver has been displaced upwards and to the right. Most of the lesser omentum has been removed or turned upwards with the stomach.

The greater part of the anterior two layers of the greater omentum has been removed, and part of the posterior wall of the lesser sac has been removed to expose a portion of the pancreas.

1. Cut surface of left lobe of liver.
2. Falciform ligament.
3. Round ligament of liver.
4. Left hepatic artery.
5. Right hepatic artery.
6. Common hepatic duct.
7. Cystic duct.
8. Fundus of gall-bladder.
9. Bile-duct.
10. Duodenum, at junction of first and second parts.
11. Transverse colon.
12. Cut edge of anterior layers of greater omentum.
13. Stomach.
14. Part of greater omentum.
15. Cut edge of lesser omentum.
16. Posterior surface of lesser omentum.
17. Caudate lobe of liver.
18. Stomach.
19. Left gastric artery.
20. Left gastric artery, on crus of diaphragm.
21. Right phrenic artery.
22. Hepatic artery.
23. Pancreas.
24. Left gastro-epiploic artery.
25. Splenic artery.
26. Gastro-duodenal artery.
27. Superior pancreatico-duodenal artery.
28. Right gastro-epiploic artery
29. Transverse mesocolon.
30. Third layer of greater omentum.
31. First layer of greater omentum.

porta. Between the duodenum and the right end of the porta, its two layers are continuous with each other, forming the free margin, which is the anterior boundary of the opening into the lesser sac.

Contents.—Several structures are enclosed between the two layers :—(1) Extraperitoneal tissue is spread throughout, and

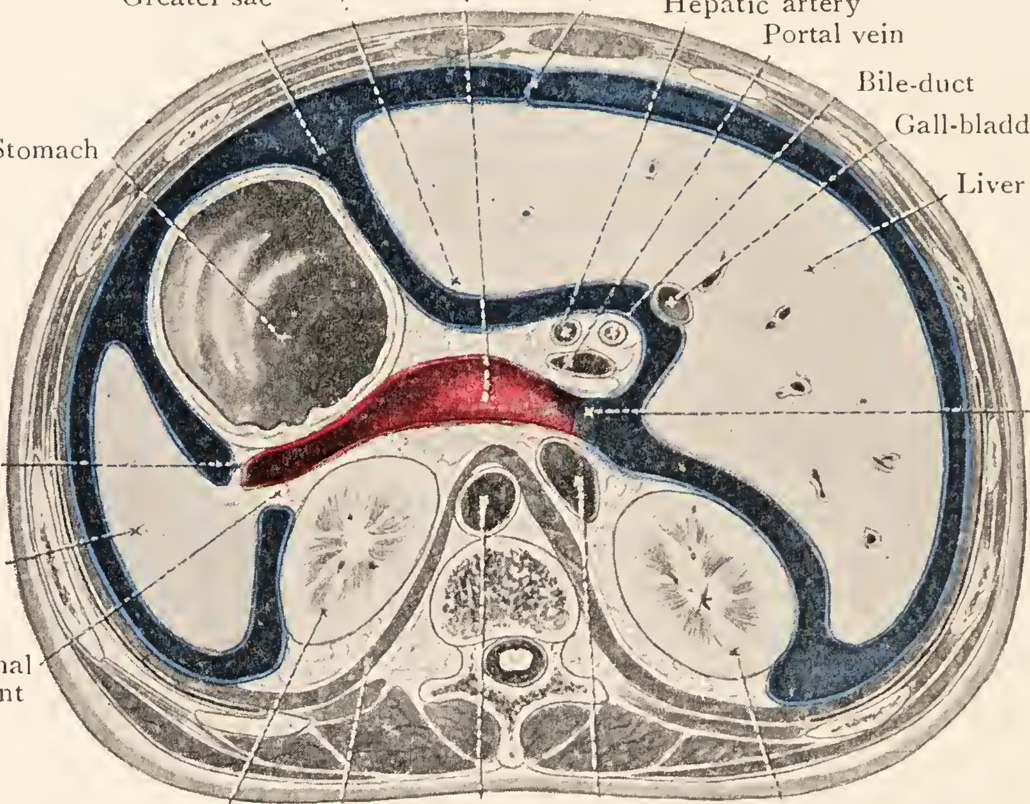

FIG. 130.—Transverse Section of Abdomen to show the arrangement of Peritoneum at the level of the Opening into Lesser Sac.

a variable quantity of fat lies in the margins. (2) The right and left gastric vessels run in it along the lesser curvature, and give branches to the stomach. (3) In the free margin, there are the portal vein, the bile-duct and the hepatic artery —the artery lying along the medial side of the duct, and the vein behind both. (4) Sympathetic nerves accompany the arteries, and fibres from the anterior gastric nerve (containing filaments of both vagi) run towards the liver in the lower part of the omentum. (5) Lymph-glands lie alongside the veins, and receive lymph-vessels from the stomach and the liver.

The dissectors will now proceed to expose first the contents of the lesser omentum, and next the structures on the posterior wall behind the part of the lesser sac that is opposite the lesser omentum. As the vessels are cleaned, look for lymph-glands and nerve-filaments.

Dissection.—In order to expose the vessels, remove as much as is necessary of the anterior layer of the lesser omentum, beginning at the middle of the lesser curvature. Trace the *left gastric vessels* towards the œsophagus till they curve backwards round the upper border of the lesser sac. Secure and trace the *œsophageal branch* of the artery up to the œsophagus. While in that region, secure the *anterior gastric nerve* on the front of the œsophagus, and trace its branches downwards.

Trace the *right gastric artery* to its origin from the hepatic artery, and the *vein* to its termination in the portal vein. Then, trace the *hepatic artery* to the porta hepatis, and follow its terminal branches into the porta. Find the neck of the gall-bladder again and secure the *cystic duct.* Follow that duct to its union with the *common hepatic duct* to form the bile-duct. Follow the common duct upwards and trace its two tributaries—the *right* and *left hepatic ducts*—into the porta ; and then trace the *bile-duct* down to the point where it disappears behind the duodenum. Push aside the bile-duct and the hepatic artery, and clean the *portal vein* down to the duodenum and up to the porta, and follow its terminal branches into the porta.

Now, without injuring these structures, remove the remains of the anterior layer of the lesser omentum and the whole of the posterior layer. Next, remove the peritoneum from the posterior wall of the abdomen opposite the lesser omentum, and carefully clean the structures exposed. Their names and relative positions are given in the following paragraphs under the posterior relations of the omentum.

Relations of Lesser Omentum.—*Anteriorly*, it is concealed by the liver, being in relation with the posterior part of the quadrate lobe and a bulging part of the left lobe called the *tuber omentale.*

Posteriorly, the lesser omentum is separated from the back wall by the cavity of the lesser sac. The lower part of the caudate lobe of the liver juts down into the lesser sac behind the omentum and, before its removal, may be seen shining through it as in Fig. 128. And, behind the lesser sac, there are numerous important structures on the posterior wall opposite the omentum, some of which are shown in Fig. 129. They are :—

1. Uppermost part of abdominal aorta.
2. A portion of the back part of diaphragm, between aorta and œsophagus.
3. Crura of diaphragm—a pair of tapering musculo-tendinous bundles—at the sides of aorta.

4. Tuber omentale of pancreas—a small, prominent portion of pancreas—on the front of aorta.

5. Cœliac artery—a short, wide artery that juts forwards from aorta immediately above pancreas, and divides almost at once into the following three branches.

6. Left gastric artery (the smallest of the three branches), running upwards on diaphragm towards the end of œsophagus.

7. Splenic artery (the biggest branch), running to the left, on left crus, immediately above pancreas.

8. Hepatic artery, running to the right, on right crus, immediately above pancreas.

9. Inferior vena cava, ascending on right crus, opposite the lower right part of lesser omentum.

10. Cœliac plexus—a thick plexus of small sympathetic nerves—on aorta around cœliac artery, and on the crura.

11. Cœliac ganglia—a pair of large, lobulated ganglia (resembling matted lymph-glands) that lie in the plexus on the crura—the right one partly hidden behind inferior vena cava.

12. Phrenic arteries—a pair of small arteries that spring from the uppermost part of abdominal aorta, and run upwards and sidewards on the diaphragm.

Lieno-Renal and Gastro-Splenic Ligaments.—The dissectors will now examine the ligaments of the spleen.

With the left hand in the upper left part of the lesser sac, pass the right hand between the diaphragm and the stomach, and find the spleen. Insinuate the right hand between the spleen and the stomach till the left hand is felt : the gastro-splenic ligament then separates the two hands. Now, pass the right hand behind the spleen, between it and the kidney, and press medially : the lieno-renal ligament is then between the two hands. (*Lien* is the Latin modification of the Greek word *splēn*.)

These two folds of peritoneum, approaching the spleen from opposite directions, are attached side by side to its hilum —*i.e.* a longitudinal groove on its visceral surface through which its vessels and nerves enter and leave it. At the ends of the hilum, these two ligaments run into each other, and their layers are continuous superiorly with the gastro-phrenic ligament, and inferiorly with the left border of the greater omentum. They were all, originally, parts of one continuous fold, called the *dorsal mesogastrium*, which connected the stomach with the posterior wall of the abdomen. But the spleen developed between the two layers of one part of the mesogastrium, and these two names have been given to the part in front of the spleen and the part behind it. The developing spleen did not bulge out the two layers equally.

It made no impression on the right layer. It bulged out the left layer, evaginating it, and, as it were, stretching it, till it clothed every part of the surface except the hilum. The two ligaments are therefore attached not to opposite borders of the spleen but close together at the hilum.

The two layers of the **lieno-renal ligament** are short. They extend from the front of the upper half of the left kidney to the hilum of the spleen, and part company there. The lateral layer passes round the spleen, adhering to its surfaces so closely that it cannot be removed without laceration of the spleen, and it comes back again to the hilum; the two layers then pass to the stomach as the gastro-splenic ligament. Besides the fat and strands of extraperitoneal tissue that lie between its layers, the lieno-renal ligament contains the splenic artery and vein, sympathetic nerves accompanying the artery, and a few lymph-glands that lie alongside the vein and receive lymph-vessels from the spleen.

The **gastro-splenic ligament** passes forwards from the hilum of the spleen to the stomach to be attached at or near the left part of the greater curvature. Besides the extraperitoneal tissue, it contains branches of the splenic artery, together with nerve-filaments, lymph-glands and lymph-vessels. The arteries are the short gastric and the left gastro-epiploic, and they are accompanied by veins.

Lien.—The position and relations of the spleen should be studied now, before the parts are further disturbed; and its main characters should be noted, although they cannot be fully examined until it is removed from the body. Pull the stomach medially, and draw the spleen forwards to obtain a view of it; as the position and relations are described, replace it, and identify with the finger-tips the structures to which it is related.

Characters.—The **spleen** is the largest of the ductless glands, and, in the living state, is a soft, pulpy, very vascular organ of a bluish-purple colour. It contains a certain amount of non-striped muscle which enables it to contract rhythmically (about once a minute) in order to promote the flow of blood through it and to alter its size from time to time. It is an organ in which changes are made in the blood, including destruction of outworn red blood-corpuscles; and it acts also as a reservoir for blood that can be added to or subtracted from the general circulation from time to time as required.

Its blood-vessels are therefore large out of all proportion to its size (the splenic artery is almost as wide as the femoral); and the size of the spleen itself varies greatly in health according to the amount of blood it contains. A spleen of average size has about the same bulk as the left lobe of the liver; but, in certain diseases, especially in the tropics, it may swell to a great size—exceeding that of the whole liver.

Position, Form and Relations.—The spleen lies obliquely in the uppermost left part of the abdomen, hidden behind the stomach, and in close relation to the diaphragm. During expiration, it is opposite the posterior parts of the ninth, tenth and eleventh ribs, with its long axis parallel to them. It varies in shape as well as in size in different subjects, and, during life, its shape alters with the varying degrees of distension of the stomach and colon. It is described as having medial and lateral ends, upper and lower borders, and two surfaces named diaphragmatic and visceral. Note that, owing to its obliquity, the names of the ends and borders do not indicate their direction precisely. For example, the medial end is directed backwards and upwards as well as medially, and the upper border forwards as well as upwards.

In a spleen removed from the body, the upper border is easily recognised from the lower, for it is sharper, and usually has one or more notches on it towards the lateral end; when the spleen is enlarged and hardened by disease, the notches may be felt through the anterior abdominal wall in the living person. The upper border terminates laterally at a projecting *angle*, which, by its relative prominence, is a guide to the lateral end; and this angle is the part of the spleen that reaches farthest forward in the body, and is sometimes visible to the left of the stomach.

The *diaphragmatic surface* also is easily recognised, for it is convex to fit the diaphragm. The diaphragm separates almost the whole of it from the left pleura, and the upper part of it from the left lung also.

The *visceral surface* is related to four viscera—stomach, pancreas, left kidney, and left flexure of the colon (Fig. 131). In a hardened spleen, the area related to each of them is indicated by a shallow impression bounded by blunt borders. The *colic impression* is small, and occupies a variable area of the lower part of the lateral end; it is at the lowest part of the spleen, and rests on the phrenico-colic ligament as well as on the left flexure of the colon. The *renal impression* is a strip of variable width that adjoins the lower border; it rests on the lateral part of the upper half of the left kidney. The *gastric impression*, wide and concave, occupies by far the largest part of the surface, extending from the superior border to the renal impression, from which it is marked off by a distinct, blunt ridge; it is related to the upper part of

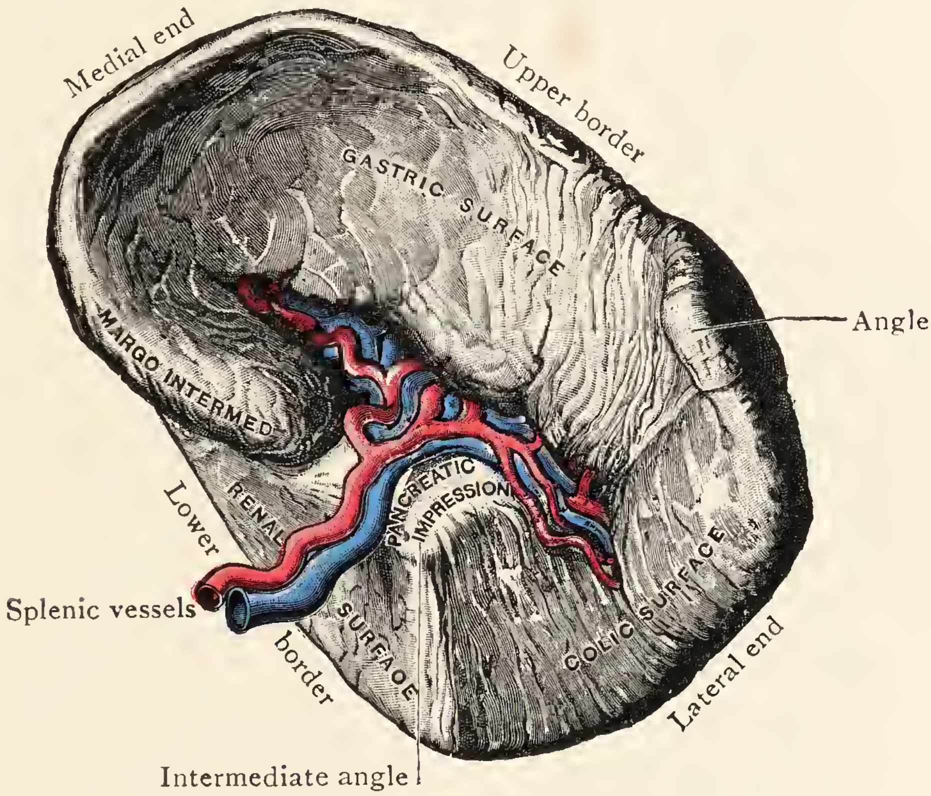

FIG. 131.—Visceral Surface of Spleen.

the back of the stomach—separated partially or wholly by the gastro-splenic ligament. The *hilum* of the spleen is in the lower part of the gastric area. It is a rough strip or groove that extends almost from end to end of the spleen immediately above the ridge between gastric and renal areas; it presents a linear series of holes—five or six—which transmit the terminal branches of the splenic artery, with the corresponding veins, the nerves, and the lymph-vessels. As already explained, the lieno-renal and gastro-splenic ligaments are attached to the margins of the hilum.

The *pancreatic impression*, made by the left end of the pancreas, is below the lateral part of the hilum; it is small, and is usually poorly-marked even in well-hardened specimens.

Occasionally two or three small *accessory spleens* are developed in the gastro-splenic ligament, and, bulging out one of the layers, appear on its surface like berries.

Structure of Spleen.—The spleen cannot be removed from the body at this stage, for it will be required when the relations of other structures are studied ; and, if it has been hardened, it is not a suitable specimen for the study of structure. But a sheep's spleen is easily procured, and the naked-eye structure can be examined in it.

First, make a section through it and examine the cut surface for some pale indistinct specks in the red mass ; then, take the specimen to a tap, squeeze the specimen as the water runs on the cut surface to remove as much as possible of the red pulpy material ; and examine the surface again.

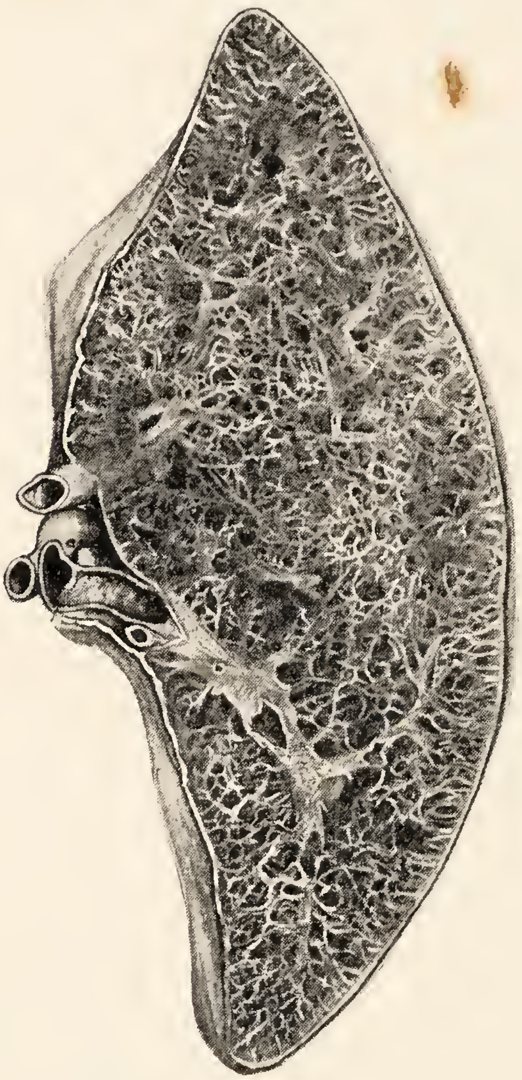

Fig. 132.—Section of Adult Human Spleen with Pulp removed to show the arrangement of Trabeculæ.

Next to its peritoneal coat, the spleen has a strong coat, called the *tunica albuginea*, made of fibro-elastic tissue and a little non-striped muscle. At the hilum, this tissue is carried into the interior as sheaths for the vessels; the sheaths are connected with the tunica on the surface by fibro-muscular strands and sheets called the *trabeculæ* of the spleen. They enclose spaces filled with soft reddish material called the splenic *pulp*. The pulp consists chiefly of blood enclosed in the meshes of a very delicate fibrous spongework. Here and there amidst the pulp there are pale specks called *lymphatic nodules*, each consisting of lymphoid tissue around a very small artery. These nodules become obvious in certain pathological conditions.

The dissectors will now complete the cleaning of the branches of the cœliac artery and trace their branches.

Dissection. — First, remove the first layer of the greater omentum near the stomach to expose the *gastro-epiploic vessels*, and trace them to the right and to the left as far as possible. At the same time, look for filaments of sympathetic nerves that form networks around the arteries, and for small lymph-glands that lie alongside the veins.

Next, identify the pylorus again. Cut through the stomach close to the *left* side of the pylorus, dividing the right gastric and gastro-epiploic vessels at the same time ; turn the stomach over to the left out of the way and fasten it with hooks or stitches to the ribs.

Now, remove the medial layer of the *lieno-renal* and *gastro-splenic ligaments*, and clean the vessels that lie in the ligaments, looking also for nerves and lymph-glands. Then, run the fingers upwards over the front of the *transverse mesocolon*, and find its attachment to the pancreas. Leave the attachment intact, and proceed to remove the peritoneum from all the structures above that level which were not exposed when the lesser omentum was studied ; as the peritoneum is removed, define and clean the structures met with ; lymph-glands in relation to the vessels must be removed with the fat and areolar tissue, but their presence should be noted—particularly the *pancreatico-splenic glands* along the upper border of the pancreas.

Clean the front of the *pancreas* first. Next complete the cleaning of the *splenic* and *hepatic arteries*, and trace their branches ; then, clean the upper part of the *left kidney* and the *left suprarenal gland*, and find the *suprarenal vessels*—three or more arteries and one vein. Clean the portion of the *diaphragm* exposed—avoiding injury to the *phrenic vessels*. The *cœliac*

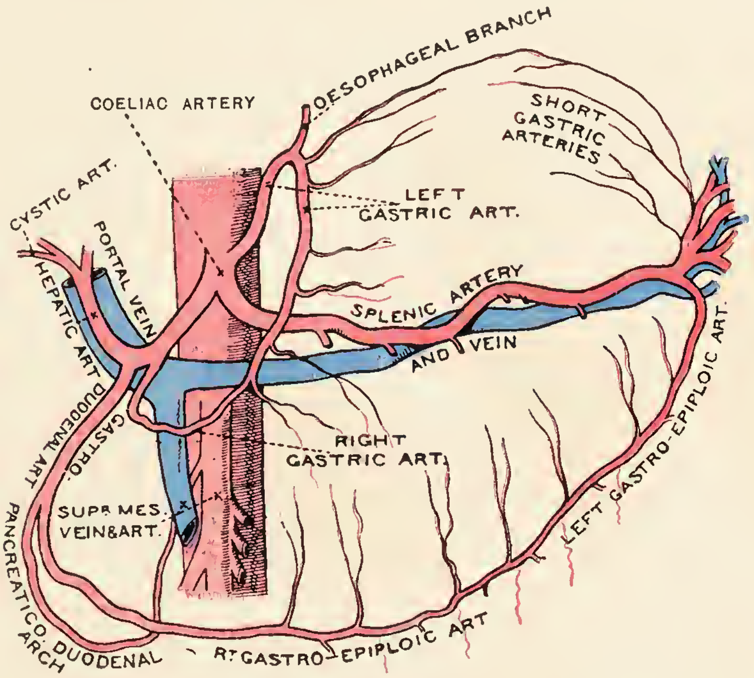

FIG. 133.—Cœliac Artery and its Branches.

ganglia have been partly exposed already ; look for the *splanchnic nerves* that pierce the crura and end in the ganglia. Secure the *posterior gastric nerve* on the back of the end of the œsophagus, and trace its branches downwards.

Cœliac Artery.—This wide vessel springs from the front of the uppermost part of the abdominal aorta, and after a very short course forwards—about half an inch—it divides into three arteries—*splenic*, *hepatic* and *left gastric*—which diverge widely from one another, and are distributed to the lowest part of the œsophagus, the stomach, the first two parts of the duodenum, the liver, the pancreas and the spleen. The cœliac artery is between the crura of the diaphragm, below the caudate lobe of the liver, above the tuber omentale of the pancreas, and behind the lesser sac opposite the lesser omentum. The cœliac plexus of sympathetic nerves surrounds it and sends secondary plexuses along its three branches.

Left Gastric Artery.—This is the narrowest of the three branches of the cœliac artery. It runs upwards on the back part of the diaphragm behind the lesser sac towards the œsophagus. Near the œsophagus, it leaves the diaphragm, curves forwards over the upper border of the lesser sac, and runs downwards in front of the sac, between the two layers of the lesser omentum near the lesser curvature of the stomach; it ends by anastomosing with the right gastric artery about the middle of the lesser curvature. (It is sometimes divided into two parallel vessels.) During its course it gives off:—(1) *œsophageal branches* to the lower part of the œsophagus (these may arise by a common trunk); and (2) *gastric branches* to both surfaces of the stomach.

The **left gastric vein** runs alongside its artery as far as the cœliac artery, and then accompanies the hepatic artery to the first part of the duodenum, where it ends in the portal vein. Its tributaries correspond to the branches of the artery; and the students should note that it communicates with systemic veins at the lower end of the œsophagus (p. 334).

Splenic Artery.—The splenic artery is a very wide vessel, and is the widest branch of the cœliac. It runs a very wavy course towards the left and slightly upwards, along the upper border of the pancreas, behind the lesser sac and the stomach, across the left cœliac ganglion and the lower end of the left suprarenal gland, to reach the front of the left kidney; it then passes into the lieno-renal ligament, in which it breaks up into five or six terminal **splenic** branches that enter the spleen through its hilum. It is a very important posterior relation of the stomach.

Branches.—Besides the splenic branches, it gives off pancreatic and short gastric branches and the left gastro-epiploic artery.

The **pancreatic branches** are small twigs that arise as the artery runs along the pancreas.

The **short gastric arteries** are five or six slender arteries that arise from the splenic trunk and its terminal branches. They run in the gastro-splenic ligament to the upper part of the stomach.

The **left gastro-epiploic artery** is a long branch that arises from the splenic trunk or from one of its terminal branches.

It first runs in the gastro-splenic ligament towards the stomach; it then passes into the greater omentum, and runs towards the right between its anterior two layers near the lower border of the stomach; and it ends by anastomosing with the right gastro-epiploic artery. It sends a few small branches down into the greater omentum, and numerous branches upwards to both surfaces of the stomach.

The *veins* that correspond to the branches of the splenic artery end in the *splenic vein*, which is a little lower than the artery, behind the pancreas, and will be studied later.

Hepatic Artery.—This artery runs towards the right and slightly downwards along the upper border of the pancreas, in front of the right cœliac ganglion and the inferior vena cava and behind the lesser sac, to reach the first part of the duodenum. There, it curves forwards below the opening into the lesser sac to enter the lesser omentum. It ascends in the omentum near its free border, in front of the portal vein and medial to the bile-duct (Fig. 130). Near the porta it divides into two terminal branches—the **right** and **left hepatic arteries**—which enter the porta and sink into the corresponding lobes of the liver.

Branches.—The branches of the hepatic artery, in their usual order of origin, are gastro-duodenal, right gastric, duodenal, and the right and left terminal branches; and the right terminal branch gives off the cystic artery.

The **gastro-duodenal artery** arises where the hepatic artery reaches the duodenum. It descends behind the first part of the duodenum immediately to the right of the lesser sac, first in front of the portal vein and then in a groove on the front of the neck of the pancreas; and, while still behind the duodenum, it ends by dividing into the superior pancreatico-duodenal and the right gastro-epiploic. It has no companion vein.

The *superior pancreatico-duodenal* is a small artery that curves downwards between the head of the pancreas and duodenum, giving branches to both; the companion *vein*—which is often absent—ends in the superior mesenteric vein.

The *right gastro-epiploic artery* runs towards the left between the anterior two layers of the greater omentum, near the lower border of the first half-inch of the duodenum and the lower border of the stomach; and it ends by anastomosing with the left artery. It sends numerous branches upwards to the duodenum and the stomach and a few downwards into the greater omentum. Its *vein* ends usually in the superior mesenteric.

The **right gastric** is a small artery that arises as the hepatic enters the lesser omentum. It runs towards the left, between the two layers of the lesser omentum, along the duodenum and the lesser curvature of the stomach (giving branches to them), and anastomoses with the left gastric. The *right gastric vein* lies alongside its artery and ends in the portal vein.

The *pre-pyloric vein* is a small vessel that connects the right gastric and gastro-epiploic veins. It runs downwards over the front of the pylorus, and can be seen shining through the peritoneal coat of the pylorus in the living abdomen. Its importance is surgical: when the pylorus is obscured by diseased thickening of adjoining parts of the stomach and duodenum, this vein is a means of recognising which part of the thickening is the pylorus.

The **duodenal branch** of the hepatic artery arises in the lesser omentum, and descends to supply the end of the first part of the duodenum and the beginning of the second part; it is peculiar in that it does not anastomose with its neighbours.

The **cystic artery** arises from the right terminal branch of the hepatic, runs along the cystic duct to the gall-bladder, and divides into two branches which ramify on its two surfaces. The *cystic vein* ends in the right branch of the portal vein.

Occasionally, the hepatic and left gastric arteries, as they run towards the duodenum and stomach, raise up ridges of peritoneum called the *gastro-pancreatic folds*.

Abdominal Part of Œsophagus.—The **œsophagus** pierces the fleshy part of the diaphragm behind its central tendon, immediately to the left of the median plane, and, inclining farther to the left, ends almost at once by joining the stomach; its right margin passes evenly into the lesser curvature, while the left margin is separated from the fundus by a notch (Figs. 68, 134). The very short portion between the diaphragm and the stomach fits into a groove on the back of the left lobe of the liver, while posteriorly it is related to the diaphragm and the left phrenic artery. Œsophageal branches of the left gastric vessels are related to its right margin; and the gastric nerves pass through the diaphragm with it—one in front and one behind.

Gastric Nerves.—The vagi nerves break up in the lower part of the thorax to form a network around the œsophagus called the œsophageal plexus—the left vagus chiefly on its front and the right vagus chiefly on its back—and they are supplemented by a few sympathetic filaments derived from the right and left greater splanchnic nerves. Two cords emerge from the lower part of the plexus and descend through the diaphragm with the œsophagus. As stated above, one of these cords is in front of the œsophagus and the other is behind ; they are named accordingly the *anterior* and *posterior gastric nerves* ; each of them contains fibres of both vagi and a few sympathetic filaments. See pp. 37 and 118 ; and Figs. 37 and 64.

The **anterior gastric nerve** ramifies on the front of the stomach, supplying it ; it sends branches also to the duodenum and pancreas, and branches which run in the lower part of the lesser omentum to the liver.

The **posterior gastric nerve**, when it enters the abdomen, divides into two parts. One part ramifies on the back of the stomach. The other runs downwards over the diaphragm to the cœliac plexus, whence offsets of that plexus which accompany branches of the aorta convey its fibres to viscera —liver, pancreas, kidneys, suprarenal glands and intestines.

The dissectors will now pass to the study of the stomach.

Release the stomach from the ribs and restore it to its place, and fasten the left lobe (which was removed) to the rest of the liver with long pins. When the posterior relations of the stomach are to be examined, the stomach and left lobe require to be displaced again.

Ventriculus or **Gaster.**—The **stomach** is an important organ known to everyone, and yet it has not been given a permanent name to which it alone has always had the right. No Anglo-Saxon name for the human stomach has survived. *Ventriculus* was a Latin name for it, but meant also the belly. " Stomach " was only one of the meanings of the Greek word *gastēr*, from which we have the adjective *gastric*.

The word *stomach* has now a fixed and limited meaning in strict English, but it is the shortened form of the Greek word *stomachos*, which originally meant the same as *stoma* (the mouth), was used also as a designation for both the throat and the gullet, and only later came to be applied to the part of the digestive tube that we now call the stomach.

General Form and Position.—The stomach is a roomy part of the digestive tube, being the receptacle into which swallowed solids and fluids are received and in which the primary processes of digestion take place. It is normally the most dilatable organ in the body—enlarging to a great size with a generous meal or when fermentative processes in the food set free a quantity of gas. As the stomach empties, the tonicity of its muscular walls reduces it again, and it shrinks into a more or less tubular form when it is empty. It is the first of the abdominal subdivisions of the alimentary canal; it receives the food through the œsophagus, and passes it on, partly digested, into the duodenum. At its upper part, it is fastened to the diaphragm by the œsophagus. Its lower end is less firmly fixed, because of its connexion with the duodenum; the greater part of the duodenum is, indeed, closely attached to the posterior wall of the abdomen, and thus moors the stomach; but the first inch of the duodenum enjoys considerable mobility because it is clothed both back and front with peritoneum, and it acts there-

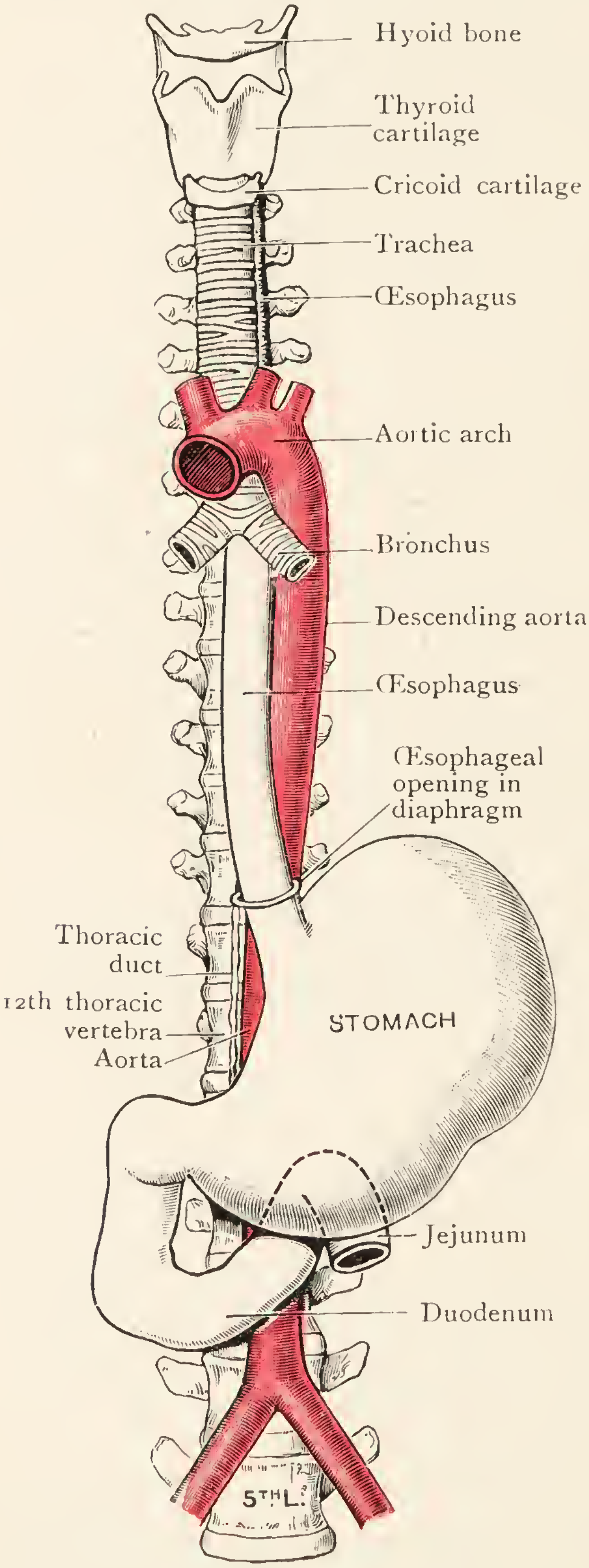

FIG. 134.—Œsophagus, Stomach, and Duodenum.

fore as a mooring-chain with some give and take. The lower end of the stomach can thus move up or down as the position of other organs requires; and it can move appreciably downwards and to the right as it fills with food.

The stomach lies in the upper left part of the abdomen; it is obliquely situated so that its upper part is well to the left

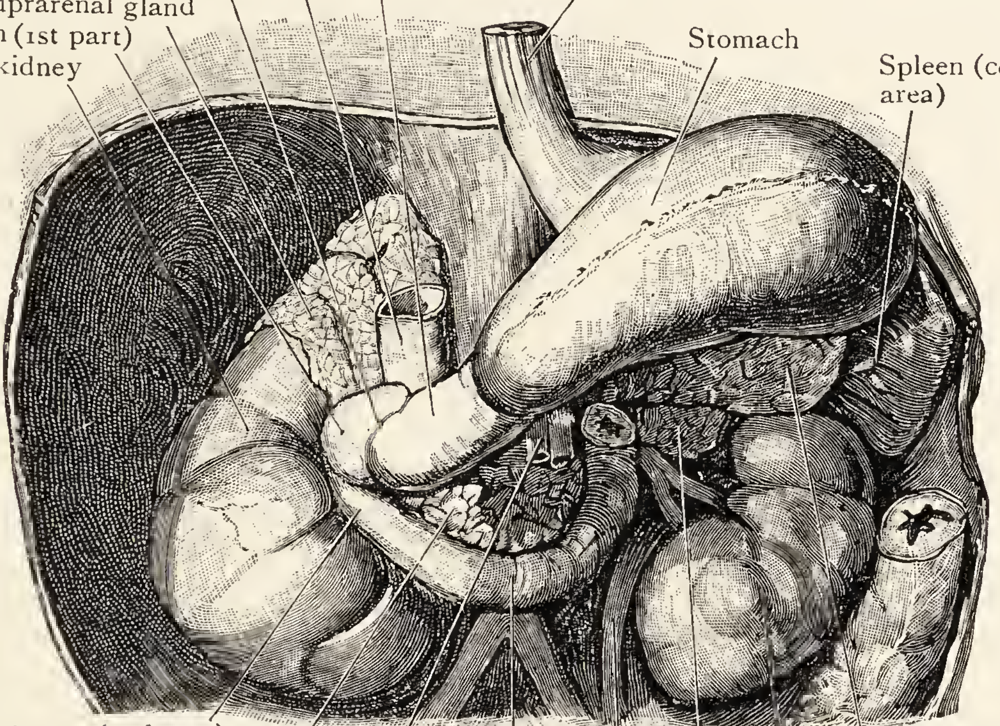

FIG. 135.—Horizontal Position of the Stomach in a Child two years old. Viscera hardened by formalin-injection. Note the relatively large size of the kidney, and the still larger relative size of the suprarenal gland.

of the median plane, and its lower end encroaches on the right half of the abdomen, especially when it is full. It is partly to the left of the liver and partly below the liver, which overlaps it in front also; and a large part of it is under shelter of the ribs of the left side (Fig. 120).

It is more or less pear-shaped in outline, with the blunt end above and to the left; but it is curved on itself, for it extends first downwards and slightly forwards and then curves towards the right, with a final inclination backwards and upwards to join the small intestine. In the dissecting-room, it is usually found empty, with its lower part nearly horizontal, but with its long axis passing with a fairly uniform sweep from upper to lower end.

Divisions.—The stomach has two ends—upper and

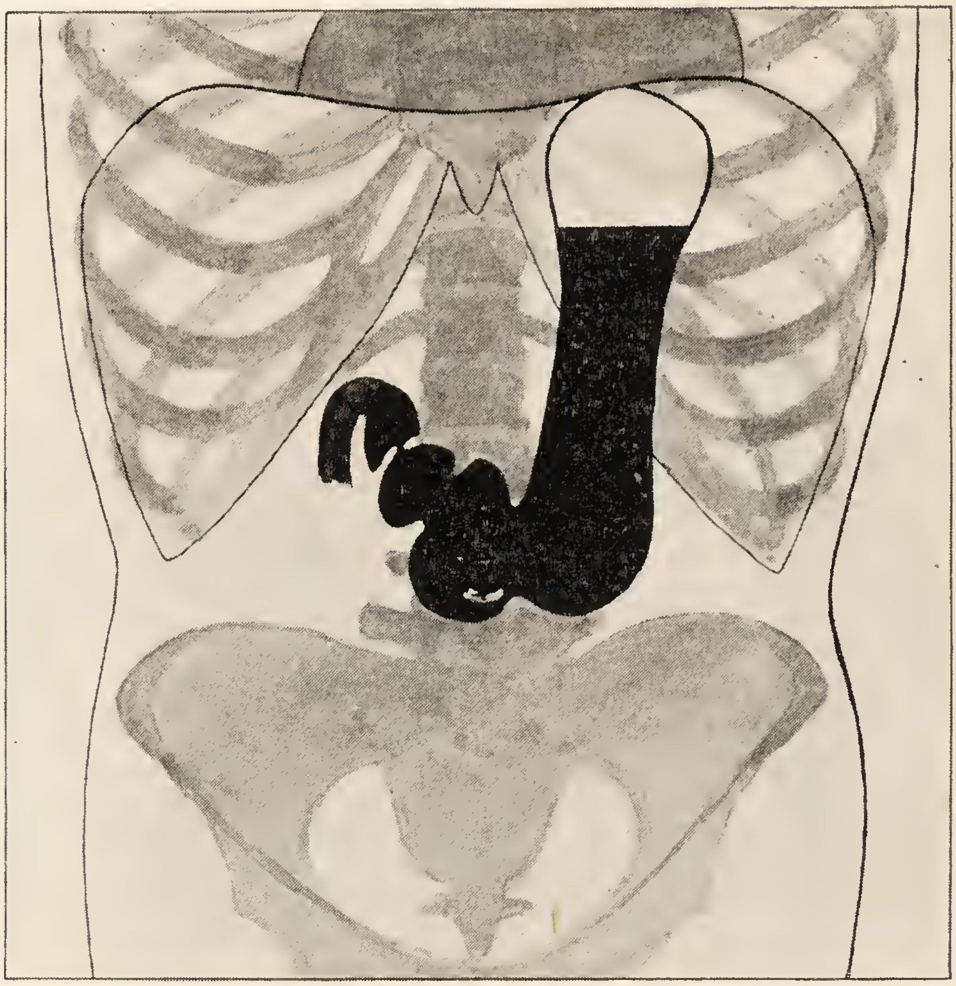

FIG. 136.—Drawing from Radiograph of Normal J-shaped Stomach as seen in the erect attitude after an ordinary barium meal. The constrictions seen near the pylorus are not permanent; they are caused by peristaltic waves, and are omitted from the other drawings. The position of the pylorus and the "duodenal cap" and a portion of the second part of the duodenum are also shown.

The tracings for this and Figs. 140 and 141 were made orthodiagraphically, and are therefore to scale and not distorted. (A. F. Hurst)

lower; two surfaces—anterior and posterior; and two borders called its curvatures—a greater and a lesser. And it is divided into fundus, cardiac portion, body, pyloric antrum, pyloric canal and pylorus.

The œsophagus joins the stomach on its right side near its upper end. The *fundus* is the full, rounded, uppermost part—the part above the level of the œsophageal junction. The

PLATE XV

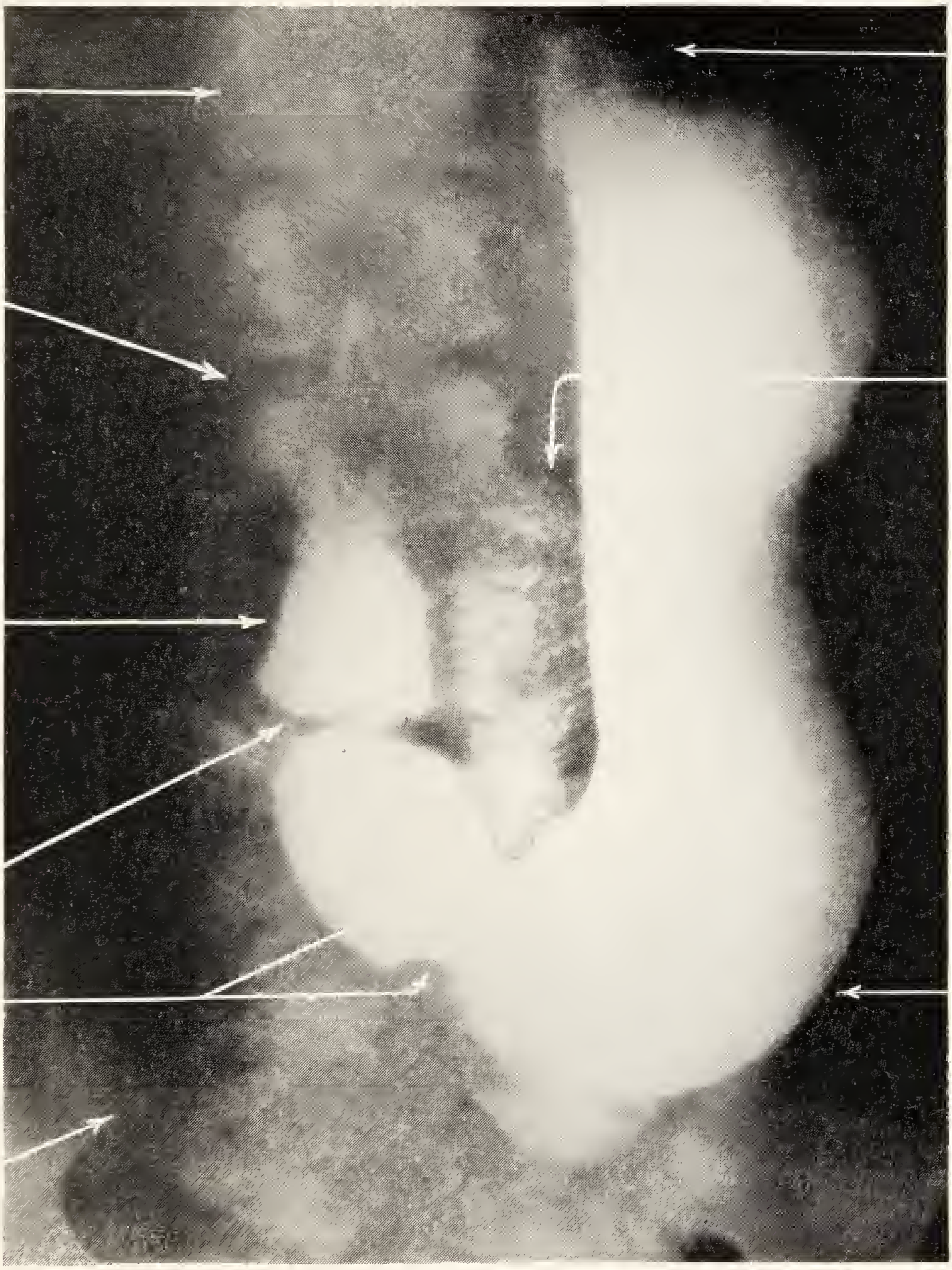

FIG. 137.—Radiograph of J-shaped Stomach of woman aged 42, taken in the erect posture 5 minutes after an opaque meal.

(Dr. J. F. Brailsford)

Note the low positions of the Greater Curvature, the Pylorus, and the Duodenum. Cf. Figs. 136, 138, 139.

PLATE XVI

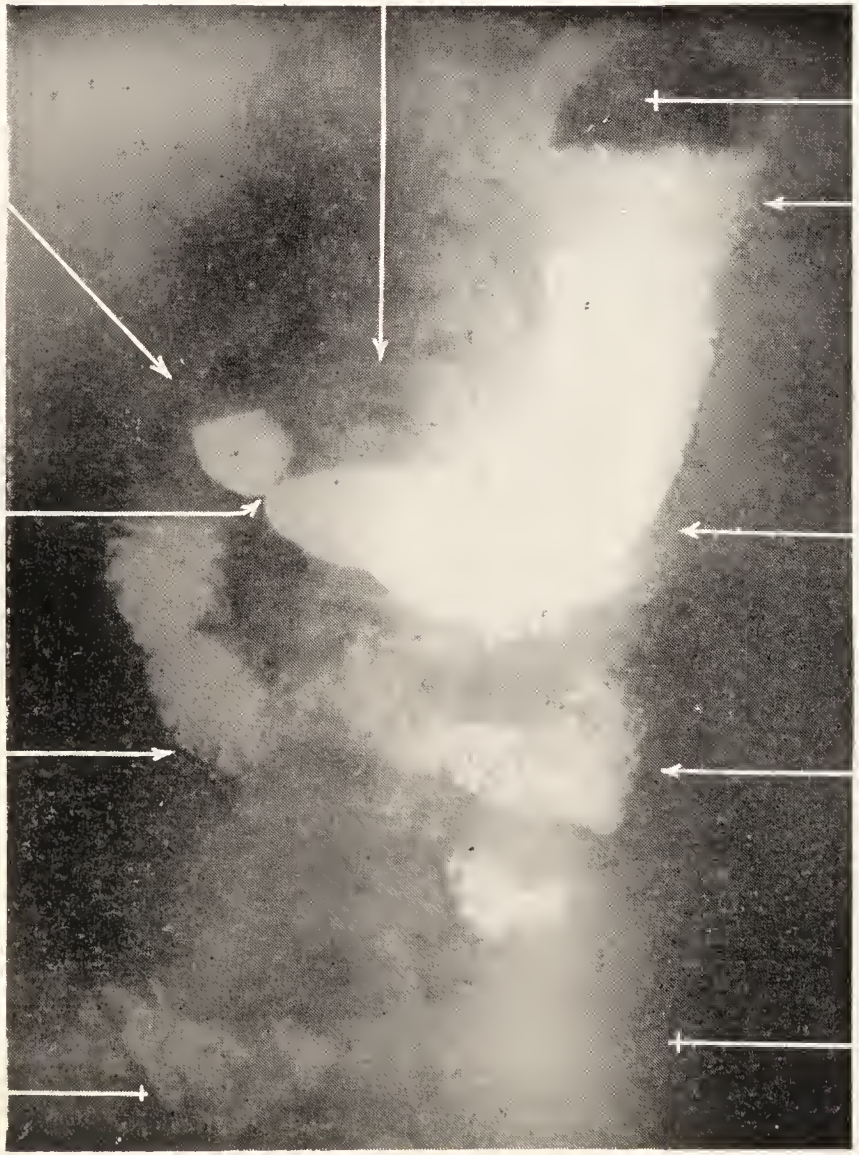

FIG. 138.—Radiograph of Abdomen of man aged 28, in the erect posture after opaque meal, showing intermediate form of Stomach. Cf. Fig. 137, and note the differences in level of the Greater Curvature, the Pylorus, and the Duodenum. A previous opaque meal, taken 3 hours before, is seen in the Ileum.

FIG. 139.—Radiograph of "Steer-horn Stomach" (Dr. R. McWhirter). The Stomach lies almost transversely, high in the abdomen; the Pylorus and the "Duodenal Cap" are hidden by the Pyloric Portion. The position of the gas in the Fundus shows that the radiograph was taken in the erect posture. Cf. Figs. 137 and 138.

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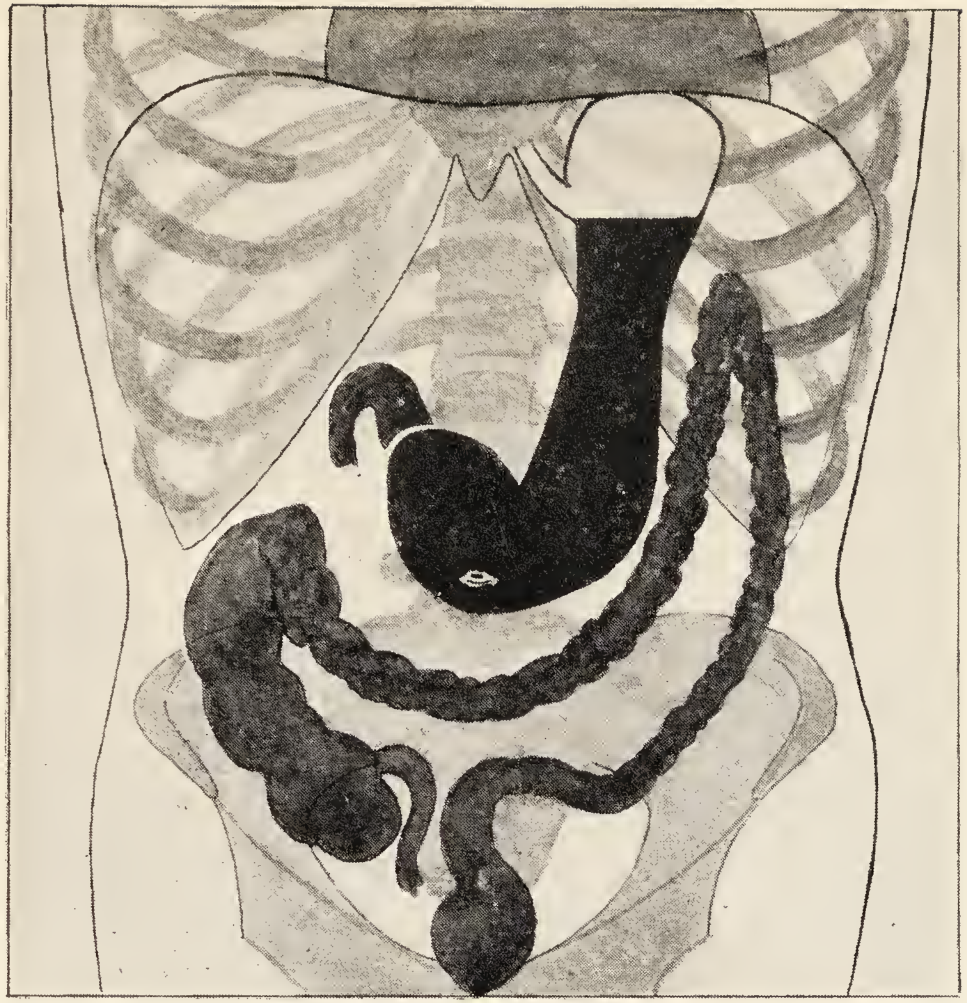

FIG. 140.—Normal J-shaped Stomach as seen in the *erect attitude* without the contractions shown in Fig. 136. (A. F. Hurst)

The lighter shadow is a composite drawing taken at varying periods after the meal, showing the appearance of the lowest part of the ileum and the large intestine as the opaque contents were passing through. Note the low position of the cæcum.

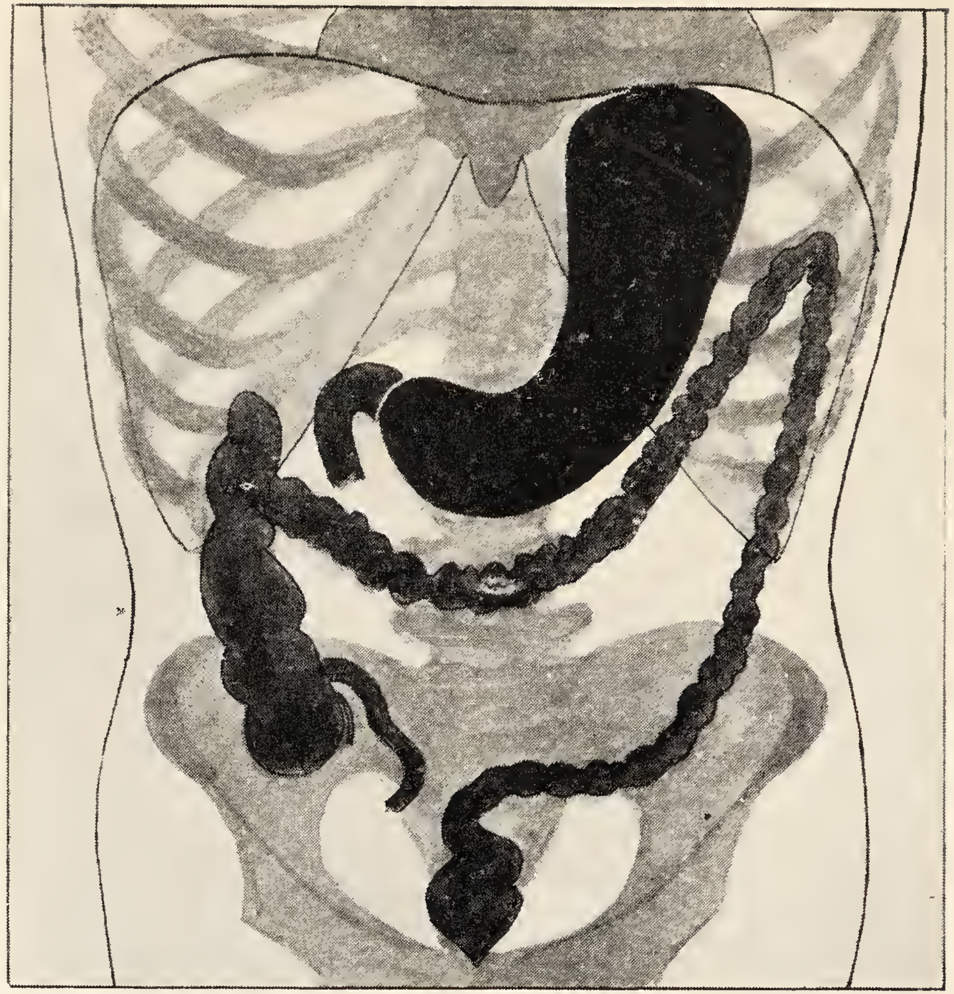

FIG. 141.—Normal J-shaped Stomach as seen in the *supine position*. Cf. Fig. 140, and note the apparent change in the form and position of the stomach. (A. F. Hurst)

The lighter shadow is a composite tracing of the ileum and large intestine taken as in Fig. 140. Note the position of the cæcum in the iliac fossa.

opening that receives the œsophagus is called the *cardiac orifice* of the stomach, and the part immediately adjoining the orifice is the *cardiac portion* of the stomach. The *body* is, of course, the main part of the stomach. The *pylorus* is the terminal half-inch, and its opening into the duodenum is the *pyloric orifice.* The pylorus has thicker walls than the rest of the stomach owing to a sudden increase of the circular muscle-fibres in the walls. This thick ring of muscle is called the *pyloric sphincter*; it closes the orifice, and relaxes periodically when the lower part of the stomach contracts to squirt

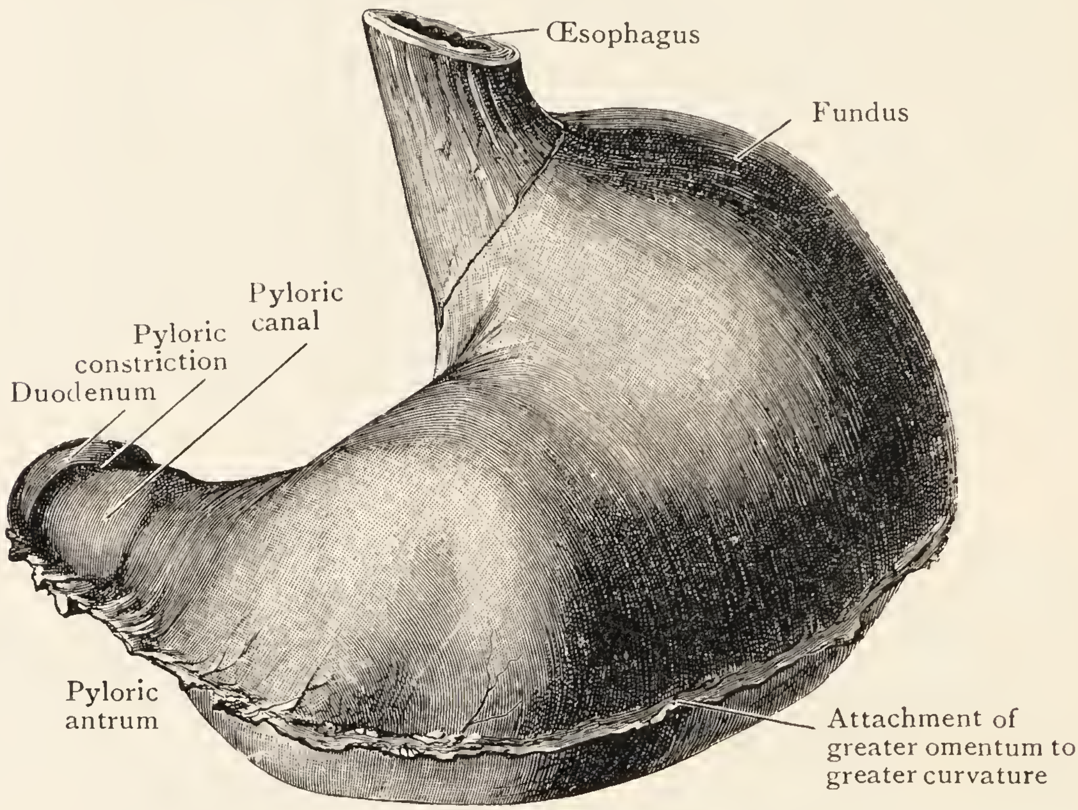

FIG. 142.—Stomach of a Child, two years of age, hardened *in situ* by formalin-injection.

its semi-digested contents into the duodenum. (*Pyloros* = a gatekeeper.) When the pylorus is relaxed, during life, the pyloric orifice can admit a finger. The pylorus is further marked by a slight annular groove on its surface called the *pyloric constriction.* The *pyloric canal* is not the cavity of the pylorus : it is the part of the stomach that immediately precedes the pylorus ; it is about one inch long, and is nearly cylindrical. The *pyloric antrum* is a variable dilatation at the lower border of the stomach, immediately to the left of the pyloric canal.

The *anterior surface* looks upwards as well as forwards, and is wholly clothed with peritoneum. The *posterior surface* looks downwards as well as backwards. It is not always wholly clothed with peritoneum; the peritoneum may be reflected on to the diaphragm from a level a little below and to the left of the cardiac orifice, leaving the part adjoining the orifice bare; this *bare area* is in direct contact with the diaphragm.

The curvatures extend from the cardiac orifice to the pylorus. The *lesser curvature* is the concave border; it looks partly to the right and backwards, and partly upwards. The

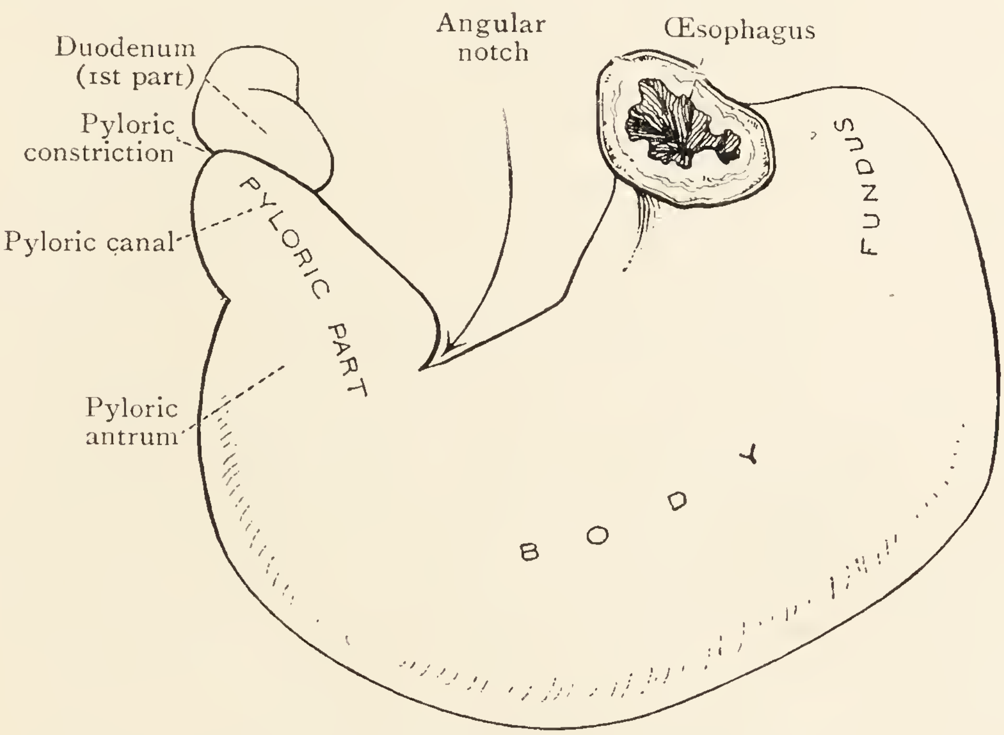

FIG. 143.—Outline of upper aspect of Stomach shown in Fig. 142.

greater curvature is the convex border, and its direction varies —first upwards, next towards the left, and thirdly downwards and forwards. When the stomach is sharply bent, there is a distinct *angular notch* on the lesser curvature opposite the pyloric antrum. The depression on the greater curvature that marks the junction of the body and pyloric antrum may be a distinct notch; and sometimes the whole stomach is constricted at the level of those notches, giving it an hour-glass appearance. Constrictions at other parts, giving great variability to the outline of the empty or half-empty stomach, are commonly seen in the dissecting-room (Fig. 144), and are probably due to localised shrinking of the muscle caused by the embalming liquid. They are to be distinguished from the physiological constrictions of the living stomach (Figs. 136-139)—phases of which, however, some of them may simulate.

Form and Position in the Living Subject.—The form and position of the stomach vary even more in the living than in the dead. These variations are of two kinds :—(1) Permanent differences—especially in the level and direction of the pyloric portion—which seem to depend on the body-build or "habitus" of the individual. (2) Temporary alterations

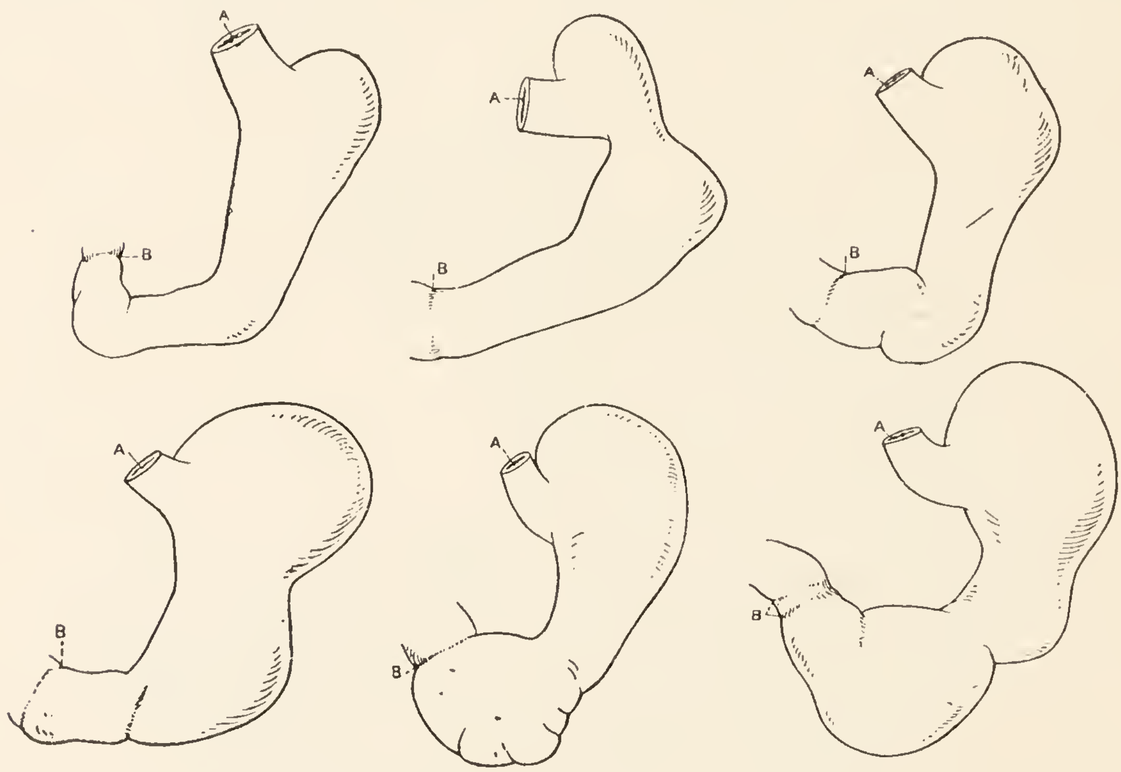

FIG. 144.—Anterior Views of six Stomachs removed from dissecting-room subjects. A, Œsophagus ; B, Pylorus.

which depend on the degree of its distension and also on the position of the body as a whole.

These differences and alterations are appreciated best by the X-ray screen-examination of a succession of persons who have taken radio-opaque "barium meals"—or by the more leisurely comparison of radiographs of their abdomens. In the supine position, the lower part of the empty stomach will generally be found to be more or less horizontal ; but its form and the level of the pylorus vary even in that position. When the erect attitude is assumed, the pyloric portion descends, the body of the stomach becomes more vertical, and in all but a few people the whole organ, even if empty, then presents the typical J-shaped outline which is seen in many people even in the supine position. If the stomach is now filled, it elongates as well as widens ; and, to accommodate its increased length between its relatively fixed ends, it descends almost vertically beyond the level of the umbilicus, even into the pelvis, and then bends upwards and to the right to reach the duodenum. The axis of a normal full stomach is therefore very distinctly J-shaped (Figs. 136, 137, 140). Very often also, the pylorus, and the duodenum as well, may be seen at a lower level in the abdomen than is usually observed in the dissecting-room (Fig. 137).

During a screen-examination, peristaltic waves may be seen passing along the pyloric portion of the stomach ; coincident with some of these, the pyloric sphincter relaxes, and the contents begin to pass into the small intestine, producing the appearance known as the " duodenal cap."

If the supine position is now assumed, the lower part of the stomach moves towards the diaphragm, and the pyloric portion may roll over and obscure the duodenal cap. The J-shaped stomach then tends to assume the shorter form and more horizontal position found in a few people even in the erect attitude (cf. Figs. 138 and 141) ; an extreme degree of this form and position produces the type of stomach known to the radiologist as the " steer-horn " type.

The " steer-horn " stomach (Fig. 139) is very uncommon, and owes its form to the fact that, in the erect attitude, no part of the greater curvature descends below the level of the pyloric portion, and that portion itself is situated at a high level in the abdomen. It resembles the dissecting-room stomach more closely than the J-shaped form does, for the cadaver is embalmed usually in the recumbent position. Indeed, the pylorus of the living " steer-horn " stomach, radiographed in the erect attitude, is very frequently in the " transpyloric plane "—which was originally determined by the average position of the pylorus in the recumbent cadaver (Fig. 120, p. 245)—and this statement is true also of any stomach whose pyloric portion remains more or less horizontal.

Peritoneal Connexions.—The layers of peritoneum that clothe the back and the front of the stomach meet at the lesser curvature, and pass away, as the *lesser omentum*, to be attached to the liver and to the diaphragm. They meet also at the greater curvature, and pass away as one great fold. Different parts of this fold receive different names according to their attachments—*gastro-phrenic ligament*, attached to the diaphragm; *gastro-splenic ligament*, to the spleen; and *greater omentum* (after doubling), to the transverse colon.

Relations.—As the stomach is a dilatable and movable organ, its relations vary, and students may find more related structures in one cadaver than another.

The *cardiac orifice* is about one inch to the left of the median plane, about four inches behind the seventh costal cartilage, and at the level of the tip of the ninth thoracic spine. The part of the stomach immediately adjoining it is related posteriorly to the back part of the diaphragm, and anteriorly to the back of the left lobe of the liver.

The *fundus* rises to a point a little below the level of the left nipple—opposite the fifth rib. It is closely related to the diaphragm, which separates it from the pericardium and the heart—and they slightly overlap the fundus anteriorly.

The *pylorus*, when the stomach is empty or only partially filled, is about one inch to the right of the median plane, opposite the first lumbar vertebra. Anteriorly, it is related to the quadrate lobe of the liver, which conceals it; and the prepyloric vein lies between its muscular wall and peritoneal coat. Posteriorly, it is related to the neck of the pancreas—separated by the lesser sac.

The *lesser curvature* gives attachment to the lesser omentum and is related to the right and left gastric vessels between its layers.

The *greater curvature* gives attachment to the gastro-phrenic and gastro-splenic ligaments and to the anterior two layers of the greater omentum; and its lower part is related to the right and left gastro-epiploic vessels between those layers.

The *anterior surface* (Fig. 120) is closely related to only three structures—liver, diaphragm and anterior abdominal wall. The portion under shelter of the ribs is related mainly to the diaphragm, but near the cardiac orifice it is separated by the liver from the diaphragm. Beyond the diaphragm, it is overlapped by the left lung, and to a greater extent, by the left pleura. The portion not covered by the ribs is overlapped in its upper part by the left lobe of the liver, while its lower part is related to the sheath of the left rectus abdominis.

The *posterior surface* is related to a number of structures collectively called the "stomach bed" (Fig. 145). These various structures are situated as follows :—(1) The body of the pancreas lies obliquely across the back wall, behind the stomach. (2) The splenic artery runs along the upper border of the pancreas. (3) A small portion of the left kidney is exposed above the pancreas. (4) The left suprarenal gland overlaps the medial part of the upper part of the kidney. (5) The spleen is lateral to those four structures. (6) The diaphragm, with branches of the phrenic vessels, is above all

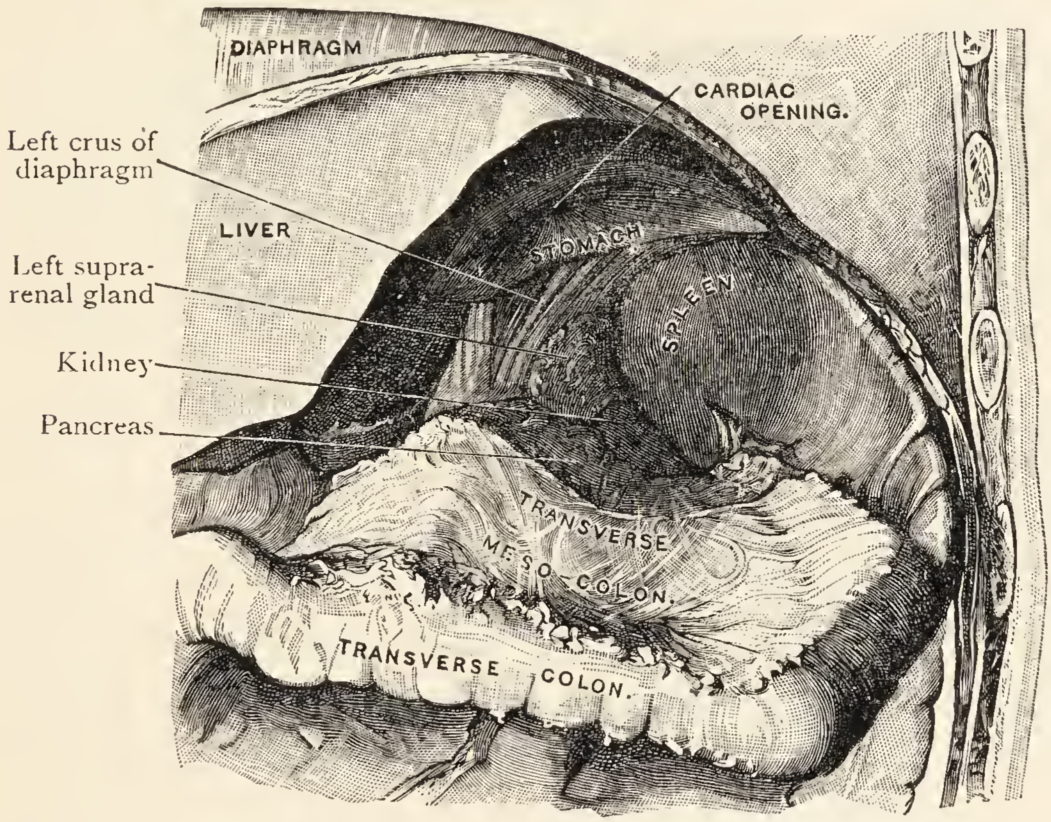

FIG. 145.—The Stomach has been removed from its bed and the recess in which it lies is displayed.

these, behind the uppermost part of the stomach. (7) The transverse mesocolon stretches down from the pancreas behind the lower part of the stomach; and the transverse colon itself may partly be behind the stomach. All these structures are separated from the stomach by the cavity of the lesser sac; and the spleen is separated by the gastro-splenic ligament also.

Vessels and Nerves.—The stomach has a rich supply of *arteries* derived from all three branches of the cœliac artery—branches of *right* and *left gastric*, at the lesser curvature; branches of the *short gastric*, to the fundus and the upper part of the body; and numerous branches (twelve or more) from the *right* and *left gastro-epiploic*, at the lower part of the greater curvature. The *veins* correspond to the arteries. The vessels run on the stomach walls almost at right angles to the long axis ; and an incision into the living stomach is made parallel to the blood-vessels.

The *nerves* are :—(1) the anterior and posterior gastric nerves—each containing fibres of both vagi and sympathetic filaments—ramify on its surfaces ; (2) *sympathetic fibres* from the cœliac plexus accompany the arteries and form plexuses around them.

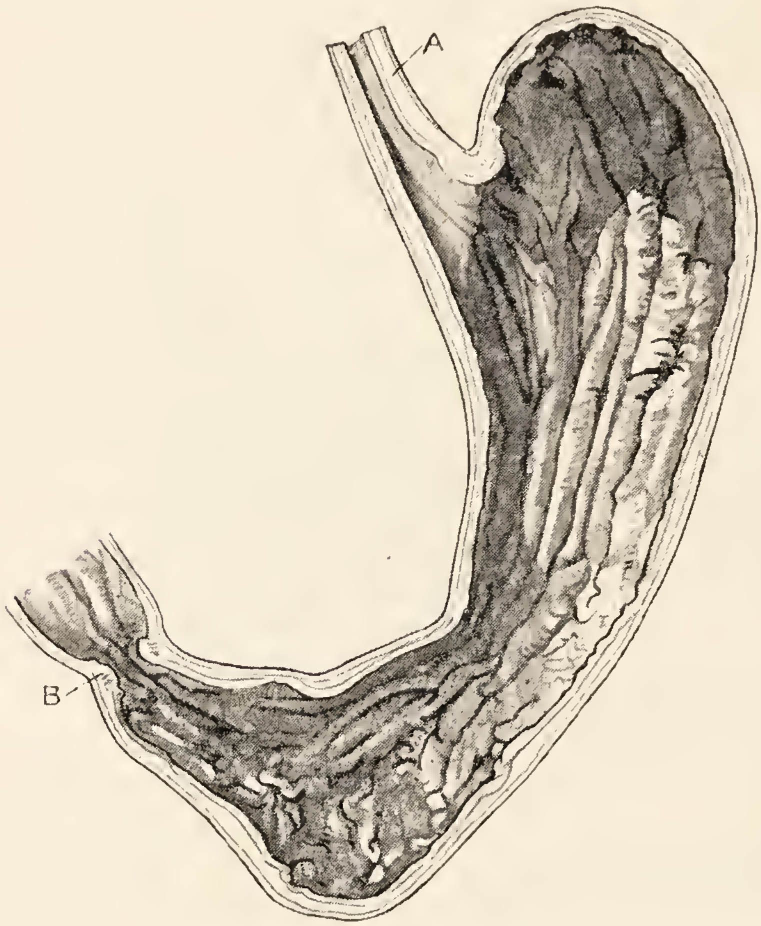

FIG. 146.—Posterior Wall of an Empty and Contracted Stomach. Showing the folds of the mucous membrane.

A, Œsophagus ; B, Pylorus.

The *lymph-vessels* proceed in different directions to the nearest lymph-glands. These lymph-glands lie alongside the vessels whose branches supply the stomach ; and they transmit the lymph to the lymph-glands that lie on the posterior wall of the abdomen in relation to the pancreas.

The dissectors should now remove the stomach from the abdomen and study its structure so far as it can be displayed by dissection.

Dissection.—Cut through the œsophagus immediately below the diaphragm and divide the left gastric vessels. Sever the gastro-phrenic ligament and the remains of the gastro-splenic ligament and the anterior layers of the greater omentum.

Remove the stomach to a table ; strip off the peritoneum from a wide belt across one of its surfaces, and note that the muscle fibres run longitudinally near the curvatures, but are circular in the middle. Then, slit up the stomach along the whole length of the greater curvature, and open out its two halves to expose the mucous membrane.

Structure of Stomach.—There are four layers or coats in the walls of the stomach, namely, serous, muscular, submucous, and mucous.

The **serous coat** is the peritoneal covering.

The **mucous coat** is a soft membrane of considerable thickness, for it

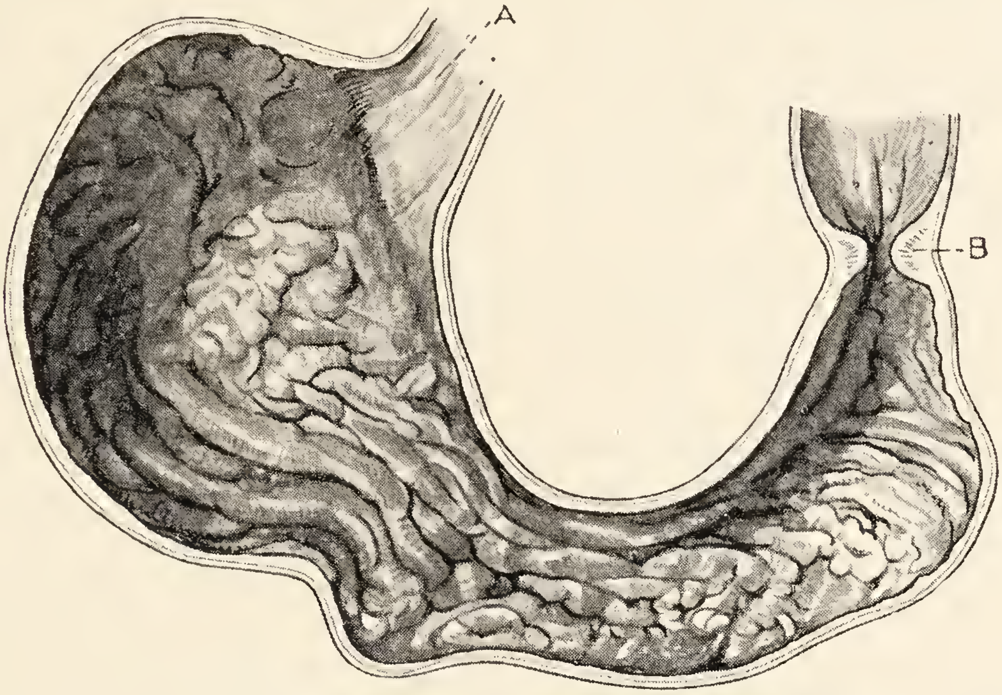

FIG. 147.—Anterior Wall of a slightly distended Stomach. Showing the folds of the mucous membrane.

A, Œsophagus ; B, Pylorus.

consists chiefly of innumerable tubular *glands* placed side by side with their ducts opening on to the mucous surface—their mouths giving it a honeycomb appearance when the surface is sponged and examined with a pocket-lens. (The rough side of a piece of tripe is the mucous mem-

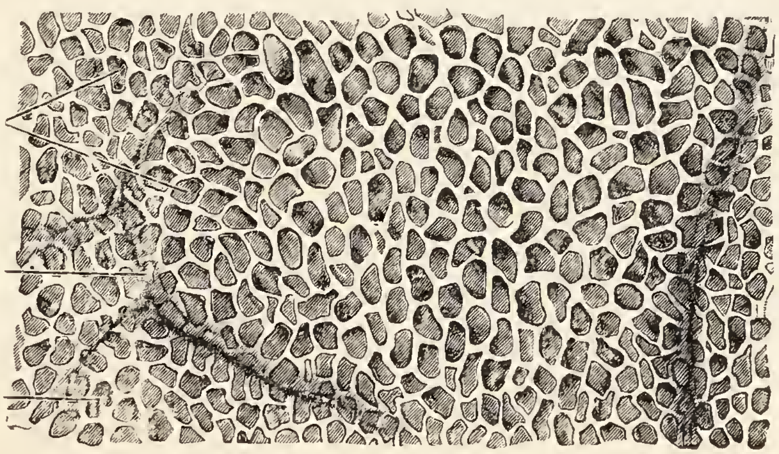

FIG. 148.—Mucous Membrane of Stomach magnified 25 diameters.

brane.) When the stomach is distended the mucous membrane is fairly smooth ; but it has little elasticity and is therefore thrown into folds or *rugæ* when the stomach is empty and contracted. These folds have mainly a longitudinal direction (Figs. 146 and 147), and those along the lesser curvature should be specially noted : the two best-marked of them form the boundaries of a narrow groove along which liquids and the first mouthfuls of a meal pass from the œsophagus towards the pylorus.

The glands are bound together by fine *areolar tissue* which contains some *lymphoid tissue* in the deeper part of the membrane. The deepest part of the mucous coat is a thin layer of non-striped muscle called the *lamina muscularis mucosæ*; this lamina is thickest at the pylorus, where it probably assists in closing the orifice.

The **submucous coat** is a layer of areolar tissue which binds the lamina muscularis mucosæ to the muscular coat. It contains networks of the vessels and nerves that supply the mucous coat.

> ***Dissection.***—Divide the stomach completely into two parts by slitting it up along the lesser curvature. Strip the mucous coat off one of the parts, and clean the inner surface of the muscular coat.

The **muscular coat** is arranged in three layers of non-striped muscle, and in that respect differs from other parts of the alimentary tube, which have only two—an outer longitudinal and an inner circular. The layers of the stomach are an outer, a middle, and an inner.

The *outer layer* is composed of longitudinal fibres which are continuous with the longitudinal fibres of the œsophagus and duodenum. They are best marked along the curvatures, while along the middle of each surface, the layer is either absent or exceedingly thin. At the pylorus, some of the deeper fibres bend inwards into the substance of the sphincter, and probably serve to open the pyloric orifice when food is sent through it.

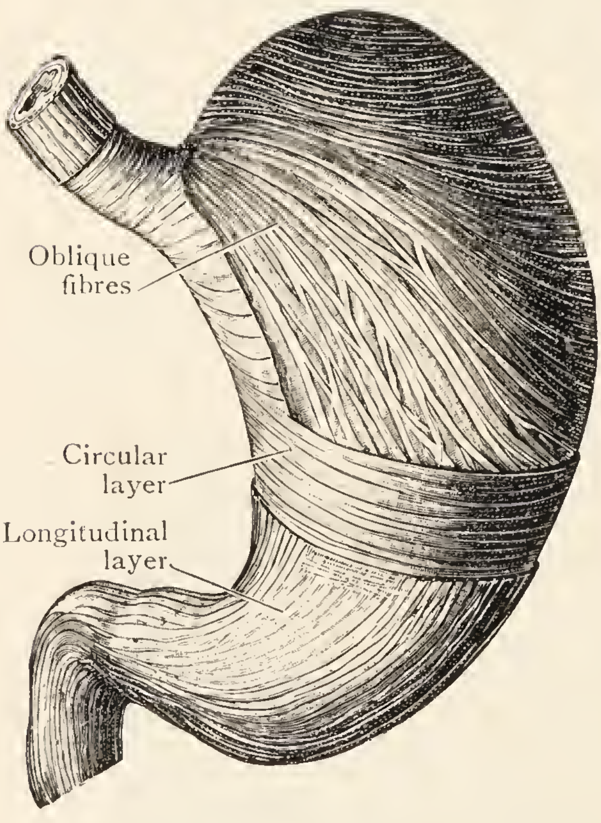

FIG. 149.—Dissection of Muscular Fibres in Wall of Stomach.

The *middle layer* is a complete layer of circular fibres. They are continuous with the circular fibres of the œsophagus. In the pyloric canal (Fig. 151), a thickening of the middle layer begins and gradually increases till the pylorus is reached, where it is accentuated to form the *sphincter*, and then abruptly diminishes—the outer fibres only being continuous with the much thinner circular layer of the duodenum.

The *inner layer* is incomplete, and is made of oblique bundles of fibres that hang in inverted loops from the right part of the fundus. The lateral bundles fan out towards the greater curvature as they descend ; the medial bundles descend along the lesser curvature, forming two fairly definite muscular ridges on the anterior and posterior walls. These ridges lie in the folds of mucous membrane that run along the lesser curvature, and when they contract they bring the edges of the mucous folds together, converting the groove between them into a canal.

The dissectors should now return to the abdomen and examine the pyloric sphincter and orifice.

Dissection.—**Make a window in the anterior wall of the first part of the duodenum close to the pylorus—sufficiently large to enable you to see the pyloric orifice. Then, split the pylorus.**

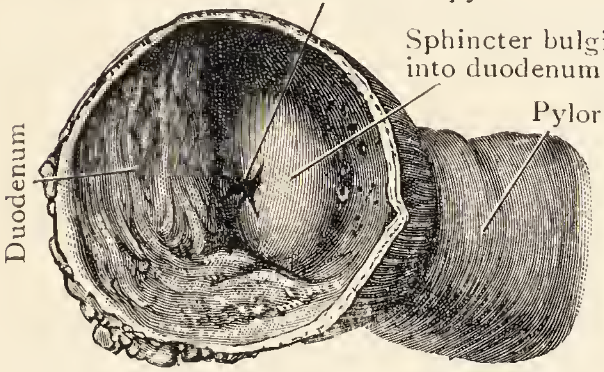

FIG. 150.—Pyloro-Duodenal Junction.

The pyloric sphincter bulges the mucous membrane inwards (Fig. 151), forming an annular ridge that either closes the pyloric orifice or reduces it to a width that varies with the degree of contraction. If viewed from the duodenal side when the orifice is closed, this thick ring is in the form of a rounded knob that bulges into the duodenum; and the orifice is a pit in the centre of it (Fig. 150). It thus resembles the os uteri externum.

Having completed the examination of the stomach, the dissectors will pass to the study of the intestines and the folds

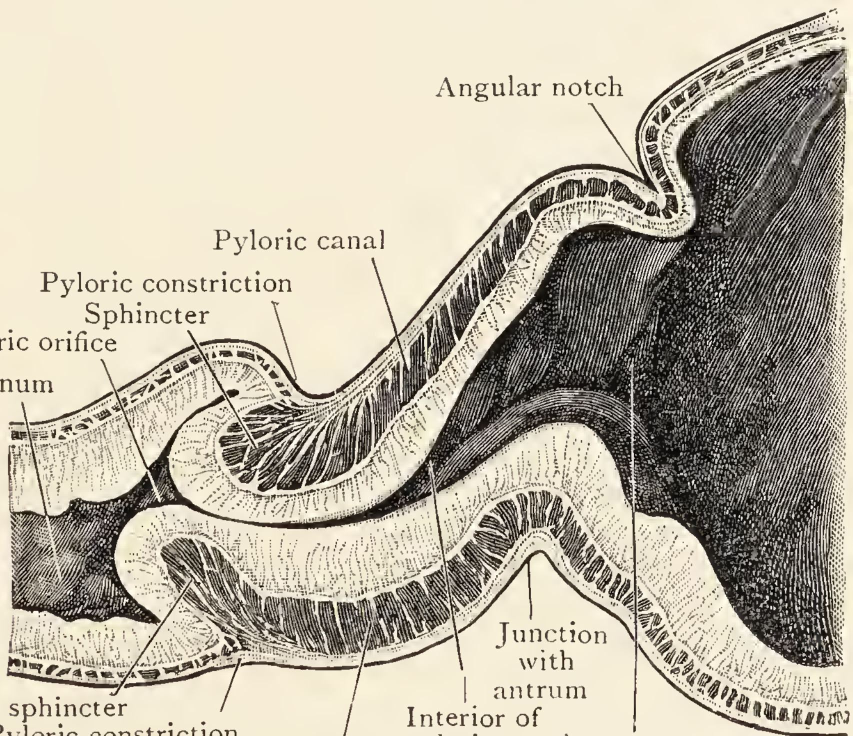

FIG. 151.—Pyloric Canal and Pyloric Antrum opened up by section in the plane of the two curvatures of the stomach.

of peritoneum connected with them, and will dissect their vessels and nerves.

Dissection.—**Throw the transverse colon and mesocolon upwards and pull the jejunum and ileum over to the left side.**

Incise the right layer of the mesentery along the whole length of its root, and remove the whole of the right layer. Expose the *superior mesenteric vessels* in the root, and follow their branches and tributaries to the jejunum and ileum, clearing away the fat and the *lymph-glands* (which are very numerous) and preserving some of the multitude of *nerves* that run with the vessels and form networks in the mesentery ; preserve the superior mesenteric vein, but remove its tributaries if they are in the way.

Then, remove the peritoneum from all the area bounded by (1) the root of the mesentery, (2) the ascending colon, and (3) the beginning of the transverse colon and the root of its mesocolon. Clean the structures exposed ; while the vessels are being cleaned, look for the lymph-glands that lie near them, and for the sympathetic nerves that surround the arteries in networks.

The following structures are laid bare in this dissection (Fig. 163). Note that, though not mentioned in the following list, there are nerves and veins with the arteries, and lymph-glands alongside the veins :—

1. The third part of the *duodenum*.

2. The lower part of the *head of the pancreas*, above the duodenum (including a portion of the head called the *uncinate process*, which, however, is hidden behind the superior mesenteric vessels).

3. The *superior mesenteric artery*, descending to the mesentery, and then running downwards and to the right in its root, giving off the following four branches (besides its jejunal and ileal branches).

   4. The *middle colic artery*, entering the transverse mesocolon.

   5. The *inferior pancreatico-duodenal artery*, running to the right between the pancreas and the third part of the duodenum.

   6. The *right colic artery*, running to the right on the duodenum or a little below it.

   7. The *ileo-colic artery*, running to the right, at a lower level.

8. A small portion of the *abdominal aorta*, immediately below the duodenum, behind the superior mesenteric artery.

9. A larger portion of the *inferior vena cava*, at the right side of the aorta.

10. A portion of a thick muscle—the *psoas major*—occupying the whole width of the area between the vena cava and the ascending colon—or nearly the whole of the area.

11. A portion of the *quadratus lumborum* muscle, in the interval between the psoas and the colon (when an interval exists).

12. A portion of the lower end of the *right kidney*, between the duodenum and the upper part of the ascending colon.

13. The *right ureter*, descending over the psoas near the vena cava.

14. The *right testicular* (or *ovarian*) *artery*, descending over the psoas obliquely across the ureter.

15. The *right genito-femoral nerve*, emerging from the psoas near the vena cava, and descending obliquely behind the ureter.

16. A thin, narrow tendon—the tendon of the *psoas minor*—descending in intimate contact with the surface of the psoas major (present, however, in only sixty per cent. of bodies).

***The* Mesentery.**—*The* mesentery is the extensive fold of peritoneum by which the jejunum and ileum are attached to and suspended from the posterior wall of the abdomen. Anteriorly, it has a free border where its two layers are continuous with each other and enclose the jejunum and ileum. This border is necessarily as long as the intestine which it

FIG. 152.—The Mesentery in a subject which was hardened by formalin-injection. The jejunum and ileum have been removed, and the foldings of the mesentery are displayed.

encloses—*i.e.* twenty feet—but this great length is not apparent, because the mesentery is thrown into undulating folds to accommodate itself to the coils of the intestine. The parietal border is called the **root** of the mesentery, and it is only about six inches in length. The depth of the mesentery from root to intestine, over a great part of its extent, is six or eight inches ; and it diminishes to nothing at each end.

Attachments.—The root extends obliquely from the duodeno-jejunal flexure to the entrance of the ileum into the large intestine, and is attached to the following structures in sequence :—(1) the fourth and third parts of the duodenum, at their junction, (2) the aorta, (3) the inferior vena cava, (4) the right psoas major and the structures on its surface—psoas minor tendon, genito-femoral nerve, ureter and testicular (or ovarian) vessels.

Contents.—The contents of the mesentery are :—(1) The intestine. (2) Extraperitoneal tissue and a variable quantity of fat. (3) Over a hundred mesenteric lymph-glands—largest and most numerous near the root. (4) Large numbers of lymph-vessels passing from the intestine to the lymph-glands (called *lacteals* because the fat in the liquid which they remove from the intestine gives them a milky-white appearance in the living). (5) Superior mesenteric vessels in the root, and their numerous branches and tributaries which supply the jejunum and ileum. (6) A very large number of soft sympathetic nerves for the supply of the intestine. This generous supply entails the cutting of a large number of nerves when a portion of the intestine is removed ; and section of the nerves partly accounts for the "surgical shock" that follows such an operation.

Superior Mesenteric Artery.—The superior mesenteric is a large artery that springs from the front of the abdominal aorta opposite the first lumbar vertebra about a quarter of an inch below the cœliac artery. It descends to the front of the third part of the duodenum, where it enters the mesentery ; and then, in the root of the mesentery, it runs downwards and to the right with a slight curve whose convexity is towards the left ; and it terminates in the right iliac fossa, near the end of the ileum, by anastomosing with a branch of the ileo-colic artery.

Relations.—Throughout its course, it is surrounded by the *superior mesenteric plexus* of sympathetic nerves, which springs from the lower part of the cœliac plexus ; and it is accompanied by its vein, which lies close along its right side either in front of the right colic and ileo-colic branches or behind them. At its origin, it is behind the body of the pancreas, and is closely related to the two large veins that cross the front of the aorta from left to right—namely, the splenic, which passes above its origin, and the left renal, which passes below it. As the artery begins its descent, it crosses in front of the left renal vein, and, after escaping from behind the body of the pancreas, it crosses in front of the uncinate process of the pancreas to reach the third part of the duodenum. During its course in the mesentery it lies on the duodenum,

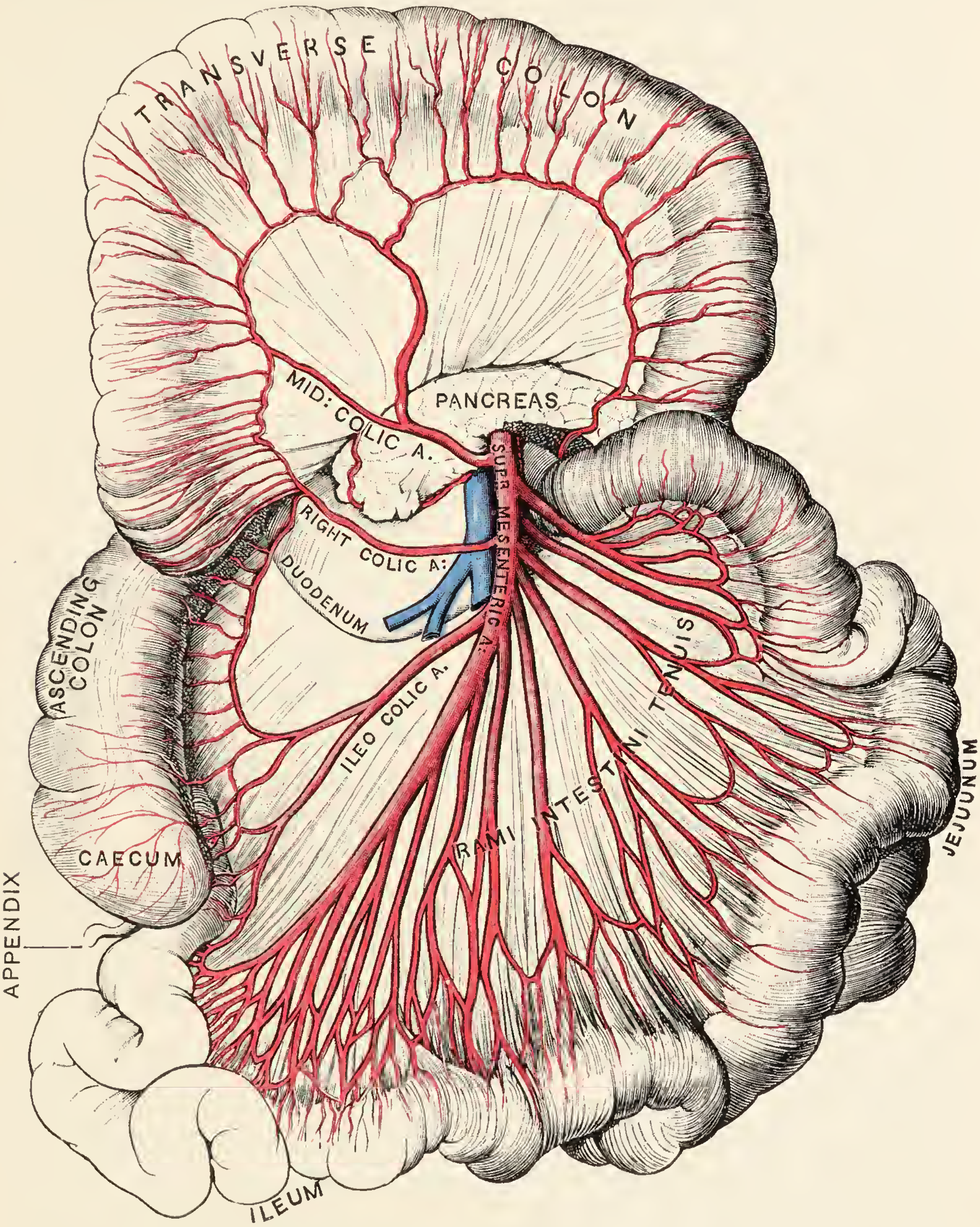

FIG. 153.—Superior Mesenteric Artery and its Branches. "Rami intestini tenuis" = jejunal and ileal branches.

the aorta, the inferior vena cava, the right psoas major and minor, genito-femoral nerve, ureter and testicular (or ovarian) vessels.

Branches of Superior Mesenteric Artery.—The branches are numerous and are accompanied by veins and by offsets of the superior mesenteric plexus of nerves. They supply the lower parts of the head of the pancreas and duodenum, the jejunum and ileum, the vermiform appendix, the cæcum, and the ascending colon and transverse colon. The jejunal and ileal branches arise from its convex or left border. The other branches arise from its concave border, and are named, from above downwards, middle colic, inferior pancreatico-duodenal, right colic and ileo-colic.

The **jejunal and ileal branches**—twelve or more in number—run obliquely towards the jejunum and ileum between the layers of the mesentery, dividing and anastomosing to form a series of *arterial arcades* ; smaller branches spring from the first series of arcades and divide and unite to form a second series, and, in the lower part of the mesentery, three or four tiers of arcades are formed (Fig. 153). Numerous small arteries spring from the last series of arcades, and, alternating with one another, pass round opposite sides of the gut, gradually sinking deeper into the substance of its walls.

The **middle colic artery** arises as the superior mesenteric escapes from behind the body of the pancreas. It enters the transverse mesocolon at once, and runs downwards and forwards in it, dividing into right and left branches. Secondary and tertiary branches arise from these, forming arterial arcades (Fig. 153). The ultimate branches supply the transverse colon ; and, towards its ends, they anastomose with branches of the right and left colic arteries. Since the middle colic vessels lie in the transverse mesocolon, they are posterior relations of the stomach.

The **inferior pancreatico-duodenal artery** is a small vessel that arises immediately before the superior mesenteric reaches the duodenum. It runs to the right between the head of the pancreas and the third part of the duodenum, giving branches to both ; and these branches anastomose with branches of the superior artery of the same name.

The **right colic artery** arises as the mesenteric trunk crosses the duodenum (Fig. 154) or (more often) immediately below the duodenum. It runs towards the right, behind the peritoneum across the duodenum, or, lower down, across the inferior vena cava, the right psoas, testicular (or ovarian) vessels and ureter. It ends by dividing into ascending and descending branches from which small arteries spring to supply the ascending colon ; the ascending branch passes over the lower part of the right kidney to supply also the right flexure and first part of the transverse colon ; the descending branch anastomoses with a branch of the ileo-colic.

The **ileo-colic artery** arises in common with the right colic or a little lower down. It runs towards the right behind the peritoneum across the vena cava and the other structures crossed by the right colic, but at a lower level. It also ends by dividing into ascending and descending branches which give twigs to the ascending colon. The ascending branch anastomoses with the right colic. The descending branch, besides supplying the colon, sends branches to the cæcum, a branch to the vermiform appendix, and a branch to the lowest part of the ileum which anastomoses with the end of the superior mesenteric artery.

The *appendicular artery* enters the lowest part of *the* mesentery, whence it passes into the mesentery of the appendix and runs in its medial free margin to reach the appendix.

Superior Mesenteric Vein.—The superior mesenteric vein is a wide vessel. Since it lies close along the right side of its artery, it has the same relations, except at its uppermost part, where it inclines slightly to the right to end behind the neck of the pancreas in front of the inferior vena cava, by joining the splenic vein to form the portal vein. Its *tributaries* are the veins that accompany the branches of the artery, and, in addition, the right gastro-epiploic vein ; occasionally, it receives the inferior mesenteric vein and a pancreatico-duodenal vein.

Lymph-Glands of the Mesentery.—The lymph-glands that lie between the layers of the mesentery are very numerous—over one hundred—and vary in size from a pin-head to a small bean. They are arranged in three main groups:—a series of small glands near the gut ; larger glands throughout the mesentery in relation to the jejunal and ileal vessels ; and a group of large glands in its root.

The **lymph-vessels** of the small intestine are called *lacteals*, and they are arranged in relays. The first relay are those which arise in the gut ; they stream in great numbers to the nearest glands, from which a second relay passes to the glands alongside the blood-vessels ; a third relay carries the lymph to the glands in the root of the mesentery. The efferent vessels of those large glands unite together to form a single vessel called the *intestinal trunk*, which ends in the cisterna chyli (Fig. 194, p. 386.)

The dissectors will now expose the structures that lie to the left of the root of the mesentery.

Dissection.—Throw the jejunum and ileum and the mesentery over to the right side, and remove the parietal peritoneum from the whole area between the mesentery and the descending colon. Then, carefully remove the fat, and clean the structures mentioned in the list below, noting the filaments of sympathetic nerves that form plexuses around the arteries, and looking for the lymph-glands that lie alongside the vessels.

The following are the structures exposed in this dissection. As in the list on p. 300, the nerves and most of the veins that accompany the arteries are omitted—and also the lymph-glands :—

1. The fourth part of the *duodenum* and the *duodeno-jejunal flexure*.
2. The lower part of the *left kidney*, in the upper lateral part of the area.
3. The lower part of the *abdominal aorta*, below the duodenum.
4. The *right* and *left common iliac arteries*, diverging from the end of the aorta, and dividing into external and internal iliac arteries.
5. A small part of the *right external iliac artery*, and a considerable part of the *left*, running along the pelvic brim.
6. The *left common iliac vein*, below and medial to its artery.
7. The *aortic plexus* of sympathetic nerves on the aorta (chiefly towards its sides), and ending inferiorly in the *hypogastric plexus*, which lies on the left common iliac vein, and divides into *right* and *left pelvic plexuses*. Take some pains to display these plexuses, for they are now of surgical importance.
8. A small portion of the *vertebral column*, to the left of the aorta.
9. A considerable portion of the *left psoas major* muscle, to the left of the vertebral bodies and also behind the external iliac artery.
10. The *left sympathetic trunk*, in the groove between the psoas and the backbone.
11. Slender *branches* to the aortic plexus, descending obliquely over the backbone *from the left sympathetic trunk*, and emerging between aorta and vena cava *from the right trunk*. These nerves also should be carefully looked for.
12. The *inferior mesenteric artery*, emerging from behind the duodenum, and curving downwards to the left common iliac artery to end on it by changing its name to *superior rectal* (superior hæmorrhoidal).
    13. The *superior left colic artery*, arising from the upper part of the inferior mesenteric, running sidewards and dividing into ascending and descending branches.
    14. The *inferior left colic arteries*—two or more—which arise from the inferior mesenteric, and run downwards and sidewards.
15. The *inferior mesenteric vein*, lateral to its artery, but ascending to a higher level to pass behind the duodeno-jejunal flexure.
16. The *left testicular* (or *ovarian*) *artery*, emerging from behind the duodenum lateral to the inferior mesenteric artery, and descending on to the surface of the external iliac artery. The corresponding *vein*, usually lateral to the artery, and diverging from it superiorly to reach the left renal vein near the kidney.
17. The lower part of the *left renal vein*, sometimes seen near the kidney immediately below the pancreas.

18. The *left ureter,* descending behind the vessels, from the kidney to the beginning of the external iliac artery

19. The *left genito-femoral nerve,* emerging from the medial part of the psoas opposite the lower part of the aorta, running downwards behind the vessels and the ureter, and dividing into two branches.

20. The tendon of the *psoas minor,* closely applied to the surface of the psoas major—present in only about sixty per cent. of bodies.

When the psoas major and the descending colon are separated by an interval, certain structures appear in the interval :—

21. A portion of the *quadratus lumborum* muscle, above the iliac crest; and a portion of the *iliacus,* below the crest.

22. The *lateral cutaneous nerve of the thigh* and iliac branches of the *ilio-lumbar artery,* at or near the iliac crest.

23. A thick nerve—the *femoral*—descending in the groove between the psoas major and the iliacus.

Inferior Mesenteric Artery.—The inferior mesenteric artery is smaller than the superior mesenteric, having a more limited distribution. Its branches supply the large intestine from the end of the transverse colon to the lower part of the rectum. It springs from the front of the aorta about an inch and a half above its bifurcation, behind the third part of the duodenum, and opposite the third lumbar vertebra. It escapes from behind the duodenum, and passes downwards and a little to the left with a slight curve, behind the parietal peritoneum, to end on the middle of the left common iliac artery by becoming the superior rectal artery.

Relations.—It is surrounded by the *inferior mesenteric plexus* of nerves, which is derived from the aortic plexus, and sends subordinate plexuses along the branches of the artery. Its vein lies on its lateral side, but not always in close contact. (Note that the two mesenteric arteries are between the two mesenteric veins). In its descent, the artery lies first on the aorta, next on the fat that conceals the left margin of the backbone and the sympathetic trunk, thirdly on the left psoas major, and lastly, on the left common iliac artery.

Branches.—Its branches are the upper and lower left colic, and its own continuation—the superior rectal, which will be dissected in the pelvis.

The **superior left colic artery** arises a little below the duodenum, passes towards the left behind the parietal peritoneum in front of the psoas, the testicular (or ovarian) vessels and the ureter ; it may be behind or in front of the inferior mesenteric vein. At a variable point it divides into ascending and descending branches from which twigs arise to supply the colon. The *ascending branch* runs obliquely upwards over the front of the lower part of the left kidney; its terminal branches supply the left flexure and the end of the transverse colon, and anastomose with branches of the middle colic.

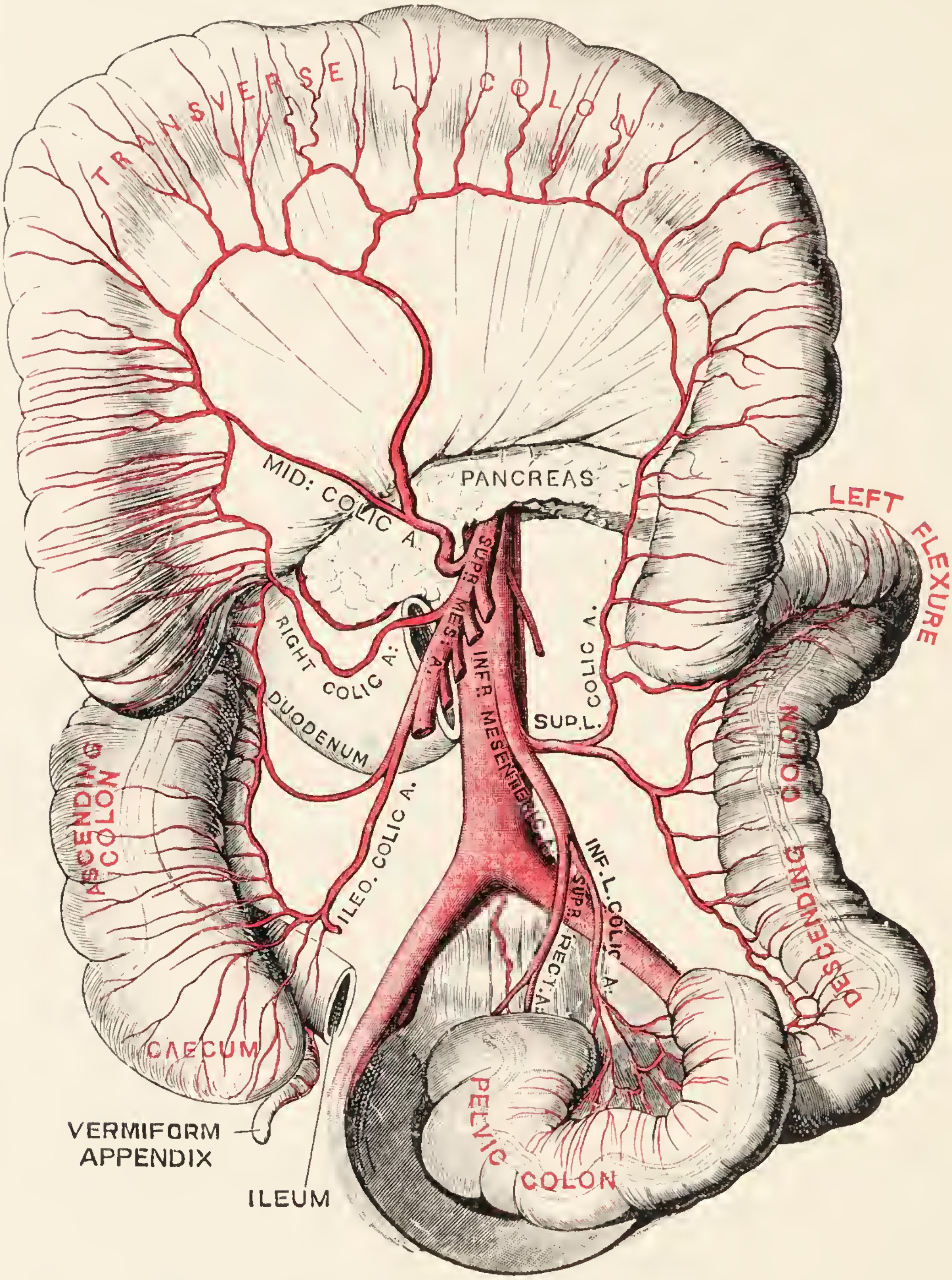

FIG. 154.—Superior and Inferior Mesenteric Arteries and their Branches. Usually, there is more than one Inferior Left Colic Artery (see Figs. 172, 191).

The *descending branch* is distributed to the descending colon, and anastomoses with the nearest inferior left colic artery.

The **inferior left colic arteries** are two or more in number. They arise at variable points from the inferior mesenteric, and pass to the left and downwards behind the parietal peritoneum in front of the inferior mesenteric vein, the left genito-femoral nerve, ureter, testicular (or ovarian) vessels and psoas major and minor. As they run they divide; the upper branches anastomose with the superior left colic and with one another, forming arches which send branches to the descending colon in the iliac fossa; the lower branches—four or five—cross the left common iliac and external iliac arteries, enter the pelvic mesocolon, and descend in it, forming one or more series of arcades from which twigs are given off to supply the pelvic colon.

The lowest branch anastomoses with a branch of the superior rectal artery—but not freely enough to maintain the blood-supply to the lowest part of the colon and upper part of rectum in the event of surgical ligature of the superior rectal artery. The surgeon therefore often ties the inferior mesenteric artery *above*, rather than below, the origin of its lowest colic branch to allow blood to reach the superior rectal artery *via* the anastomoses between the left colic arteries themselves (Figs. 172, 191).

Inferior Mesenteric Vein.—This vein is the continuation upwards of the superior rectal vein, and its *tributaries* accompany the branches of the artery. It runs upwards on the lateral side of its artery and medial to the testicular (or ovarian) vein and the ureter. It is covered by the parietal peritoneum and crosses in front of the genito-femoral nerve and the testicular (or ovarian) artery, and either in front of the left colic arteries or behind them. It is much longer than its companion artery, for it extends upwards over the psoas major behind the duodeno-jejunal flexure, and then crosses in front of the left renal vein to end in the splenic vein behind the pancreas. Occasionally, its upper part inclines sharply towards the right, passes behind the third part of the duodenum and ends behind the neck of the pancreas by joining the beginning of the portal vein or the end of the superior mesenteric. (See also p. 264.)

Anastomoses of Mesenteric Vessels.—With the important exception mentioned above, every part of the intestine is assured of a blood-supply, even if one of the arteries is obstructed; for the anastomoses among the smaller arteries are very free, and the two mesenteric systems are linked together by the anastomosis between the middle colic and upper left colic. Further, the mesenteric systems are connected with the cœliac system by (1) anastomoses of the middle and left colic with the right and left gastro-epiploic arteries at the upper parts of the right and left borders of the greater omentum, and (2) the anastomosis between the pancreatico-duodenal arteries.

Aortic Plexus.—This plexus of fine sympathetic nerves is in the form of a pair of sets of two or three inter-communicating cords that descend over the antero-lateral surfaces of the aorta and are connected with each other by slender filaments that cross the front of the aorta. They descend from the cœliac and superior mesenteric plexuses, and each set is reinforced by slender branches that spring from the lumbar part of the sympathetic trunk ; thus reinforced, they pass downwards into the hypogastric plexus. The branches to the plexus from each sympathetic trunk are usually four ; they descend obliquely in the fat at the side of the aorta in front of the lumbar arteries, and they unite into one cord which joins the lower part of the plexus. On the right side, they are behind the inferior vena cava, and the cord courses forwards between the vena cava and the aorta.

The aortic plexus gives off secondary plexuses that accompany all the branches of the aorta below the level of the superior mesenteric ; and it is continuous inferiorly with the hypogastric plexus.

Hypogastric Plexus.—This plexus is known to the surgeons as "the presacral nerve," but it is a network of nerves and lies on the fifth lumbar vertebra and the left common iliac vein between the two common iliac arteries, under cover of the parietal peritoneum. It is formed as a continuation of the aortic plexus (and is connected in that way with the cœliac and superior mesenteric plexuses and the sympathetic trunks) ; and it is reinforced by an additional filament (sometimes two) that arises from one of the lower lumbar ganglia of each sympathetic trunk and descends across the common iliac artery near its origin. It ends at or below the sacral promontory by dividing into a *right* and a *left pelvic plexus*. Each of these inclines laterally to reach and surround the internal iliac artery.

The dissectors will defer the study of the other structures that have been exposed till they are displayed in a greater part of their extent, and will now examine the structure of the jejunum and ileum.

Structure of Small Intestine.—The small intestine has four coats —serous, muscular, submucous, and mucous, from without inwards.

The **serous coat** is the peritoneum, and invests the gut completely except along the line of the mesenteric attachment. It is usually thinner than the layers of the mesentery, and is closely attached to the muscular coat by an exceedingly thin layer of extraperitoneal tissue.

The **muscular coat** is composed of non-striped muscle arranged in two layers. The *inner layer* is the thicker, and its fibres run circularly. The fibres of the *outer layer* run longitudinally; unlike the longitudinal fibres of the colon, they form a continuous layer all round the gut, but the layer is thickest on the side farthest from the mesentery.

The **submucous coat** is a layer of areolar tissue which binds the muscular and mucous coats together. Blood-vessels and nerves ramify in it.

The **mucous coat** is the lining membrane. Its deepest part is a thin layer of non-striped muscle called the *lamina muscularis mucosæ.* The epithelium (1) lines simple tubular glands, called *intestinal glands*, which are placed side by side, and are connected together by exceedingly delicate areolar tissue, with their mouths opening on the free surface; and (2) covers minute processes called *intestinal villi*, set between the mouths of the glands in such multitudes that they give the surface a velvety appearance. In many places, the glands are separated by nodules of *lymphoid tissue*—which lie partly in the submucous coat also. Throughout a great part of the small intestine, the mucous coat is thrown into *circular folds* which increase the secreting and absorbing surface about five times. The villi are agents of absorption; each contains a lymph-vessel (*lacteal*) in its centre and small blood-vessels.

The jejunum and ileum must be removed from the abdomen; but, before doing so, grip a piece of jejunum and a piece of ileum between finger and thumb, and compare them. The jejunum is the thicker, and it is empty (the word *jejunum* means empty); the ileum probably has some semi-liquid contents. Note also that the jejunum is the wider.

Dissection.—Apply two ligatures to the jejunum about an inch below the duodeno-jejunal flexure, and divide the gut between them, and then two ligatures to the ileum about six inches from its lower end, and divide it; next, cut through the mesentery and the blood-vessels close to the gut. Take the detached portion of the gut to the sink, cut away the ligatures, and clean the interior of the gut by allowing water from the tap to run through it.

Cut off a few inches of the upper part of the jejunum, slit it up with scissors along the line of the mesenteric attachment, pin it out, with its mucous surface downwards, in a cork-lined tray filled with clean water. (The jejunum is chosen because, having thicker walls, it is more easily dissected than the ileum.)

Carefully remove the peritoneal coat, and note that the subjacent muscular fibres are arranged longitudinally. Then, turn the specimen and pin it down with the mucous surface upwards. Note the plications and velvety appearance of the mucous coat, and then remove it and the submucous coat in one layer with the scissors, and note that the muscular bundles now exposed are arranged transversely.

The mucous coat, on account of its special importance, must be examined throughout the whole length of the small intestine. At present only the jejunum and ileum can be dealt with; the duodenum will be examined later.

Dissection.—First, cut off a foot of the upper part of the jejunum; tie it at both ends, and inflate it; and then hang it up to dry, in order that the arrangement of the circular folds of the mucous coat may be examined later.

Next, slit up the remainder along the line of the mesenteric attachment. The easiest way to do so is to tie the lower end of the ileum, fill the gut with water, and then slit it up with scissors—sticking a piece of costal cartilage on the point of the inner blade to prevent it from catching in the mucous membrane.

FIG. 155.—Typical part of Jejunum, showing numerous and large Circular Folds.

Mucous Membrane of Small Intestine. — It has been mentioned already that the mucous membrane is cast into *circular folds*. Unlike the folds in the stomach, these folds do not disappear when the gut is distended or stretched; and they therefore increase the extent of the mucous surface permanently. They vary both in depth and length. Most of them extend a considerable distance round the gut, but fail to reach the starting point again; others form complete rings; while a few take two or three spiral turns round the gut. They begin in the duodenum about an inch from the pylorus. They are large and closely set in the duodenum and jejunum; they gradually become fewer, less prominent and shorter in the ileum, and disappear entirely in the lower part of the ileum. Since these folds are so much larger and more numerous in the jejunum, the jejunum feels considerably thicker than the ileum; and it is redder, owing to the larger blood-supply required for the more extensive mucous membrane.

The *intestinal villi* are a little more than half a millimetre in length, and are found in all parts of the small intestine—from the beginning of the duodenum to the end of the ileum, where they cease abruptly at the ileo-colic orifice. Rinse the mucus off pieces taken from the upper and lower parts of intestine, examine the mucous surface with a pocket-lens and compare them. The villi are larger and more numerous in the jejunum than in the ileum.

The nodules of lymphoid tissue are of two kinds—solitary and aggregated. The *solitary lymphatic nodules* are rounded, whitish bodies, about the size of millet seed (Figs. 156, 157) scattered all along the mucous membrane. They usually bulge the mucous membrane slightly, but they are seen best when a piece of stretched ileum is held up to the light. The *aggregated lymphatic nodules*, as the name suggests, are formed of a large number of the small nodules closely packed together. There are about thirty of these aggregations. They are largest and most numerous in the

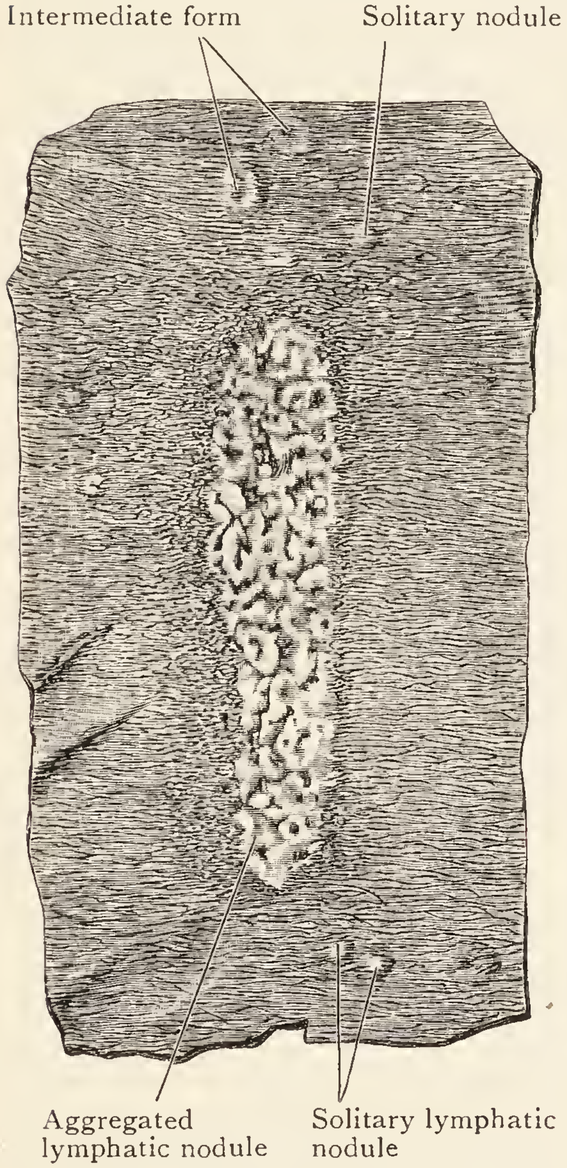

FIG. 156.—Lymphatic Nodules from the intestine of a child aged two years. (Birmingham)

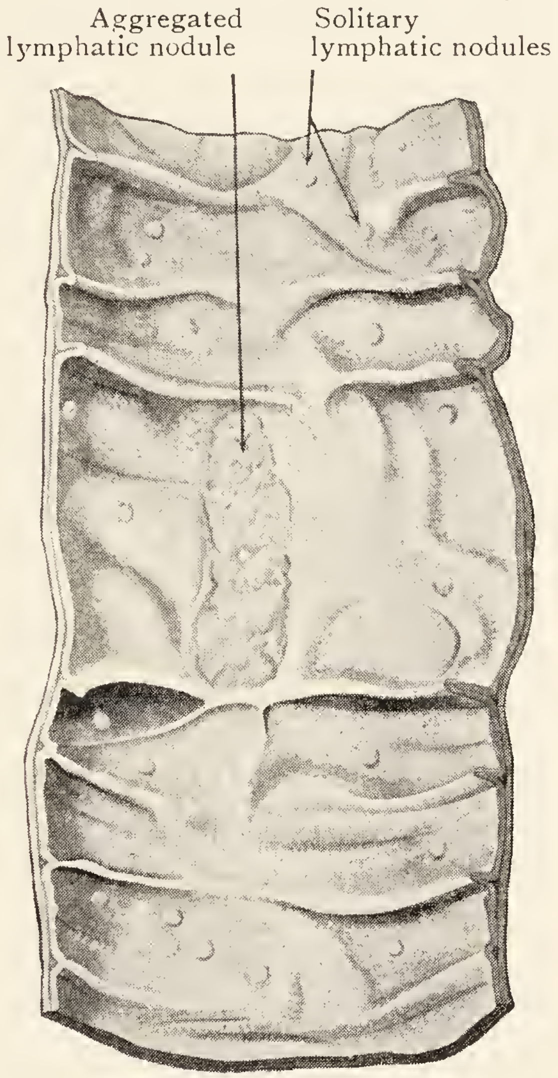

FIG. 157.—Typical part of Ileum, showing few and small Circular Folds, numerous solitary Lymphatic Nodules and one Aggregated Nodule.

lower part of the ileum, gradually diminish in the higher part, and are few or absent in the jejunum. They are placed on the side of the gut farthest from the mesentery and form indistinct elevations in the mucous membrane. The largest of them are half an inch wide, and one to four inches long, and are placed lengthwise in the intestine. Lymphoid tissue throughout the body is more abundant in youth than in old age, and both solitary and aggregated nodules are fairly well seen in young subjects, especially if the intestine was inflamed at the time of death. They become flatter with age, and can seldom be convincingly demonstrated in old subjects.

They swell in typhoid (enteric) fever, and may ulcerate ; perforation may result from the ulceration, and, since they are on the anti-mesenteric border of the gut, the contents of the intestine will pass into the peritoneal cavity and set up peritonitis.

Differences between Jejunum and Ileum.—To the surgeon, who has to make his decision from a single loop of unopened intestine, the important difference is the one that presents itself first; and that is an external one, viz., that in the mesentery of a loop of the jejunum the vessels can be seen framing "windows", whereas at the ileum the fat hides the vessels and overlaps the gut. The surgeon requires to distinguish also the proximal and distal ends of the loop, without having to trace the gut in either direction. To determine that, he need only identify the sides—right and left—of the gut by running the finger along one surface of the piece of mesentery pulled out with the loop. If the finger passes to the right (or left) when it reaches the root, it must have started from the right (or left) side of the gut (Fig. 152).

Besides the difference that is of most practical importance, there are several others, all of which have been noted already. (1) Usually some time has passed since food was last taken both before death and before a patient is brought into the operating-room ; the jejunum is therefore empty, while the ileum still retains some of its contents. (2) The circular folds are large and numerous in the jejunum and small and few in the ileum ; the walls of the jejunum are therefore thicker and redder. (3) The jejunum is usually wider than the ileum. When comparison is made between parts of the opened intestine—(4) the difference between the circular folds is obvious at a glance ; (5) aggregated lymphatic nodules in the ileum may be found with careful scrutiny ; and (6) a pocket-lens will show that the villi are larger in the jejunum.

The appearance and general arrangement of the large intestine have been considered already ; the characters and relations of its several parts must now be studied more completely.

Large Intestine.—The two main parts of the intestine are distinguished by the adjectives *large* and *small* ; yet the large intestine is very much shorter than the small intestine, and it is not, in all its parts, always the wider. It extends circuitously from the right iliac fossa to the perineum, but it is only about five or six feet in length. Like the small intestine, it is widest at its beginning, and usually diminishes in calibre as it is traced to the anus. The diameter depends upon its state of contraction at the moment ; and, while most parts are flaccid even when not distended, the descending colon, both in the living and the dead, is usually empty and contracted so that it may be no thicker than a finger—that is, narrower than the small intestine. All parts, however, with the exception of the appendix, are capable of more distension than the small intestine, and hence the adjective "large".

The parts of the large intestine are :—

The cæcum and vermiform appendix.

The colon {ascending; right flexure; transverse; left flexure; descending; and pelvic.

The rectum and anal canal.

Intestinum Cæcum.—The cæcum is the blind commencement of the large bowel. It is an asymmetrical sacculated pouch, two or three inches long, and of a varying width that is rarely less than its length and may be a little greater.

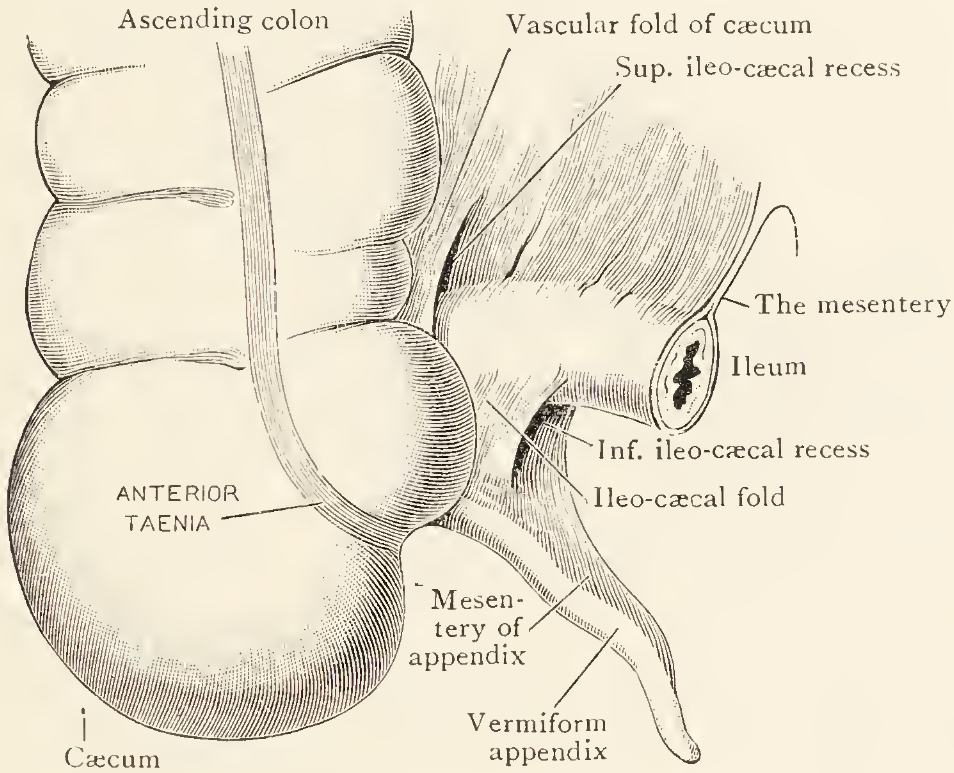

FIG. 158.—Ileo-Cæcal Region and Recesses

It is continuous superiorly with the ascending colon ; at their junction the ileum enters the medial side of the large gut ; and the vermiform process opens into the back of the cæcum about an inch lower down.

Position and Relations.—The cæcum lies in the right iliac fossa immediately above the lateral half of the inguinal ligament. Anteriorly, it is in relation with the anterior wall of the abdomen, from which, however, it may be separated by the greater omentum and coils of the ileum. Posteriorly, it rests on the ilio-psoas muscle and (very often) the external iliac artery, and on the nerves and small vessels related to those structures—lateral cutaneous, femoral and genito-femoral nerves, and the testicular or ovarian vessels. It is thus firmly supported, except medially where it is related only to yielding intestines.

It is as a rule completely clothed with peritoneum, and has therefore some freedom of movement; its position is not so constant in the living as it is in embalmed cadavera: in many radiographs, part of its shadow is seen in the true pelvis (Fig. 140).

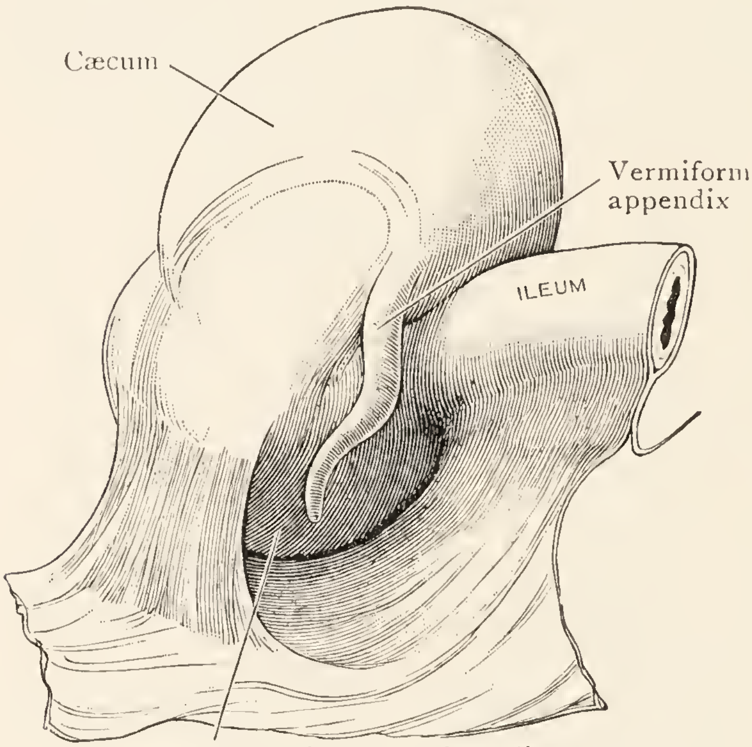

FIG. 159.—Ileo-Cæcal Region from below. The Cæcum has been turned up to show a Retro-Cæcal Recess. Note the position of the Appendix.

Vermiform Appendix (Processus Vermiformis).—The appendix springs from the back of the cæcum towards its medial side, about an inch below the end of the ileum. It is a blind tube about a quarter of an inch thick and four inches long—but may be much shorter or much longer — and its lumen is exceedingly narrow. It is enclosed in a small mesentery which is attached to the back (or left side) of the lowest part of *the* mesentery.

Position.—The appendix has no fixed position. It moves with the cæcum; and it may occupy any situation consistent with its length and mesenteric attachment. Its commonest position is below or behind the cæcum (Gladstone and Wakeley). But it often curves downwards over the psoas and the external iliac vessels into the true pelvis—which was formerly considered to be its commonest position—and, in the female, it may therefore be in close relation with the right ovary. Occasionally, it is behind the terminal part of the ileum and the mesentery. It has been explained already that, wherever the appendix may be, the anterior tænia coli, traced downwards, is a sure guide to it; for the three tæniæ meet at its root and are continued into it as a complete coat of longitudinal muscular fibres.

Vessels and Nerves.—The cæcum and the vermiform appendix are supplied by branches of the **ileo-colic artery** and by the **nerves** that accompany those branches. Their **lymph-vessels** pass to glands that lie in the mesentery of the

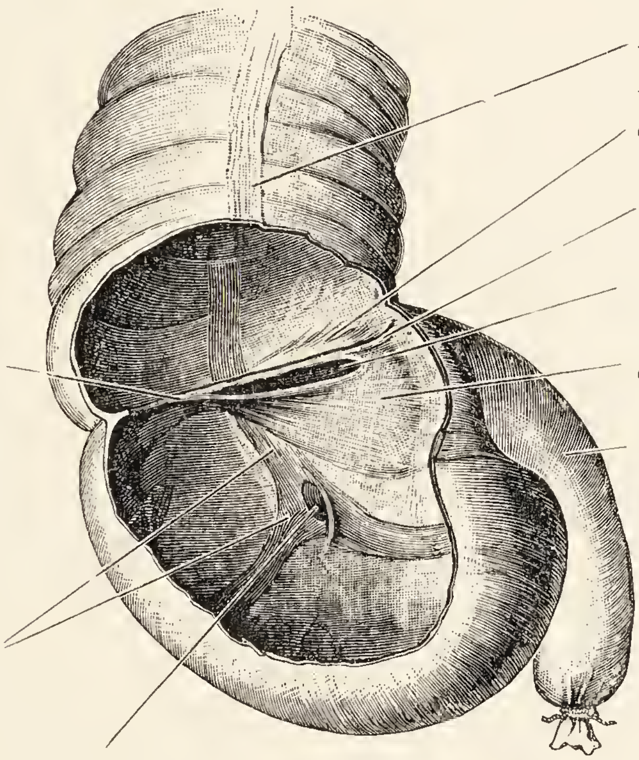

FIG. 160.—Cæcum which has been distended with air and dried, and then opened to show Ileo-Colic Orifice and Valve. (Birmingham)

appendix, in the vascular fold of the cæcum and along the branches of the ileo-colic artery as high as the duodenum.

Dissection.—Turn the cæcum upwards, remove the peritoneum from the floor of the iliac fossa behind it, and expose and clean the structures that form its posterior relations.

Cut away a portion of the lateral wall of the cæcum, and examine the ileo-colic orifice and the orifice of the appendix. Then, examine the relation of the ileum to the large intestine, and trace the postero-medial tænia coli behind the end of the ileum and onwards to the root of the appendix.

Ileo-Colic Orifice and Orifice of Vermiform Appendix.—The **orifice of the appendix** is a small opening on the back of the cæcum about an inch below and lateral to the ileo-colic orifice. It may be quite open, or it may be guarded superiorly by a small flap of mucous membrane.

In a specimen of the cæcal part of the gut which has been distended with air and dried, the **ileo-colic orifice** appears as a horizontal slit between two thin protruding lips—an upper and a lower. These lips are the two flaps of a valve called the **ileo-colic valve,** and are due to the partial invagination of the large intestine by the end of the ileum. At each end of the slit, the flaps unite together and become continuous with a ridge of mucous membrane, called the *frenulum of the valve*, which extends for some distance round the wall of the gut (Fig. 160).

In a formalin-hardened specimen (Fig. 161), the orifice is more rounded and the lips are thicker, owing to the shrinking of the sphincter-like circular muscle-fibres of the invaginating part of the ileum; and the appearance is not unlike what has sometimes been observed in the living body.

The ileo-colic valve is, however, not the kind of valve—such as exists at the orifices of the heart—whose flaps close under mechanical pressure. Its closure takes place under nervous impulse sent to the circular fibres of the ileum: the circular fibres of the last inch of the ileum control the passage of its contents into the large intestine by slow, alternating contraction and relaxation, and the circular fibres in the protruding lips contract to close the orifice and prevent reflux. This part of the circular layer of muscle is not specially thickened to form a sphincter, but it plays the part of a sphincter.

When the cæcum and colon are distended, the tension of their stretched walls may widen the orifice beyond the power of the circular fibres to close it, and mechanical factors come to their aid in the following ways:—(1) The tension of the frenula helps to close the lips. (2) Since the ileum ascends out of the pelvis, it passes upwards along the medial side of the upper part of the cæcum, and its entrance into the large intestine is therefore oblique. When the cæcum is distended the obliquity is increased, for the cæcum and ileum are then pressed close together, and the obliquity may be further accentuated by the tonic contraction of the postero-medial tænia, which passes downwards immediately behind the ileum.

Ascending Colon.—The ascending colon is from five to eight inches in length. It begins at the upper end of the cæcum in the right iliac fossa, passes upwards over the back wall of the abdomen, and ends on the front of the right kidney below the liver by bending to form the right flexure of the colon and to become continuous with the transverse colon.

Relations.—The peritoneum clothes its front and sides and binds it to the back wall; occasionally, the peritoneum is tucked in behind it to clothe almost the whole of it, and even to form a short mesentery—the *ascending mesocolon.*

Anteriorly, it is either in contact with the anterior wall of the abdomen or is separated from it by the greater omentum and coils of small intestine. It is in relation *medially* with the psoas major and the small intestine, and *laterally* with the side wall of the abdomen or with the small intestine. *Posteriorly*, it is related to a number of structures :—first, the iliacus muscle, the lateral cutaneous nerve of the thigh and the iliac branches of the ilio-lumbar artery ; secondly, the iliac crest ; thirdly, the quadratus lumborum and the ilio-inguinal and ilio-hypogastric nerves, where they lie on the front of the quadratus ; fourthly, the lower part of the right kidney ; and,

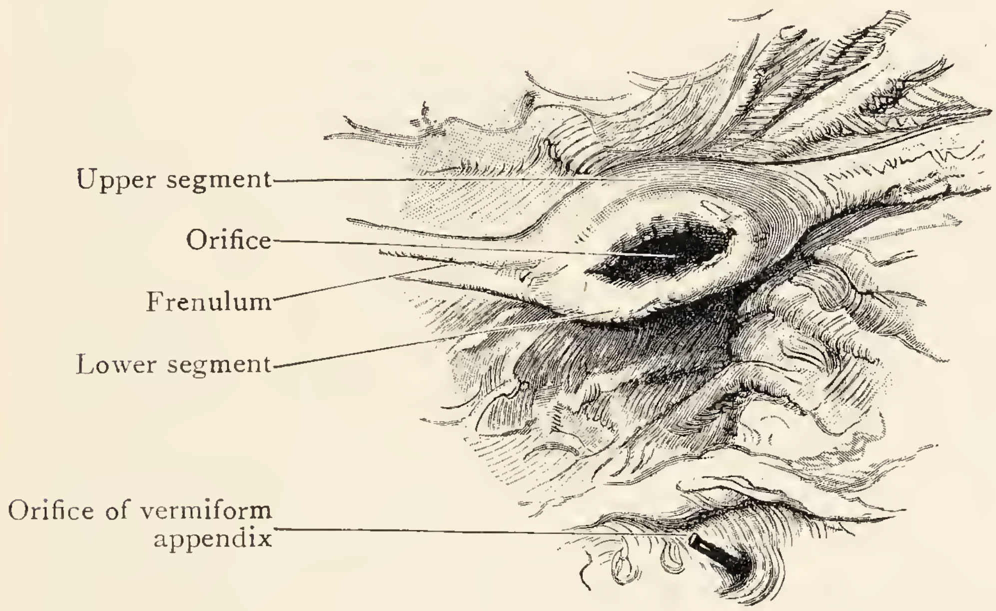

FIG. 161.—Ileo-Colic Orifice and Valve from a subject hardened by formalin injection. (Birmingham)

lastly, it is usually wide enough to overlap the transversus abdominis lateral to the quadratus and the kidney.

Dissection.—Incise the peritoneum along the lateral margin of the ascending colon ; move the colon and cæcum out of the way, and clean the structures that lie immediately behind them.

Right Flexure of Colon.—The right flexure of the colon, like the ascending colon, is clothed with peritoneum except on its posterior surface, which is in direct contact with the right kidney. It is in close relation with the right lobe of the liver, which is above it and overlaps it in front and laterally.

Vessels and Nerves.—The ascending colon and the right flexure are supplied by the ileo-colic and right colic vessels and the accompanying nerves. Their lymph-vessels end in lymph-glands that lie along the medial side of the colon and alongside its blood-vessels.

Transverse Colon.—The transverse colon begins at the right flexure on the front of the right kidney below the right part of the liver, arches across the abdomen with its convexity forwards and downwards, and ends at the lateral margin of the left kidney, immediately below the spleen, by bending sharply to form the left flexure and to become the descending colon (Fig. 162). It is the longest part of the colon (18 to 20 inches), and usually diminishes in width as it passes from right to left. Suspended by a wide mesocolon, it is also the most movable part of the colon, and the lowest part of its curve may be at almost any level in the abdomen. In many radiographs, its shadow is seen well below the level of the umbilicus. In the recumbent cadaver, it is usually found immediately above the umbilicus, near the lower border of the stomach ; but it may be lower down ; and if the intestines are distended, it may be pushed up behind the stomach, or rolled up in front of the stomach, dragging the greater omentum with it.

Relations.—In almost its whole extent, it is enclosed in peritoneum which is continuous superiorly with the transverse mesocolon and inferiorly with the posterior two layers of the greater omentum. But the transverse mesocolon seldom extends to its right end, and at its beginning the peritoneum therefore covers only its front and upper and lower surfaces, leaving the posterior surface in direct contact with structures on the posterior wall of the abdomen ; and at its left end, the mesocolon is so short that it is negligible.

The first two inches of the transverse colon lies on the second part of the duodenum and the head of the pancreas, and is overhung by the right lobe of the liver and the lower part of the gall-bladder.

The last two inches lies on the front of the left kidney, immediately below the left part of the body of the pancreas, behind the stomach or the left margin of the greater omentum.

The remainder, in the recumbent position of the body, is in front of the third part of the duodenum and coils of the jejunum, below the stomach, and behind the anterior two layers of the greater omentum, from which it is separated by the cavity of the lesser sac of the peritoneum.

Transverse Mesocolon.—This fold of peritoneum has to a

PLATE XVII

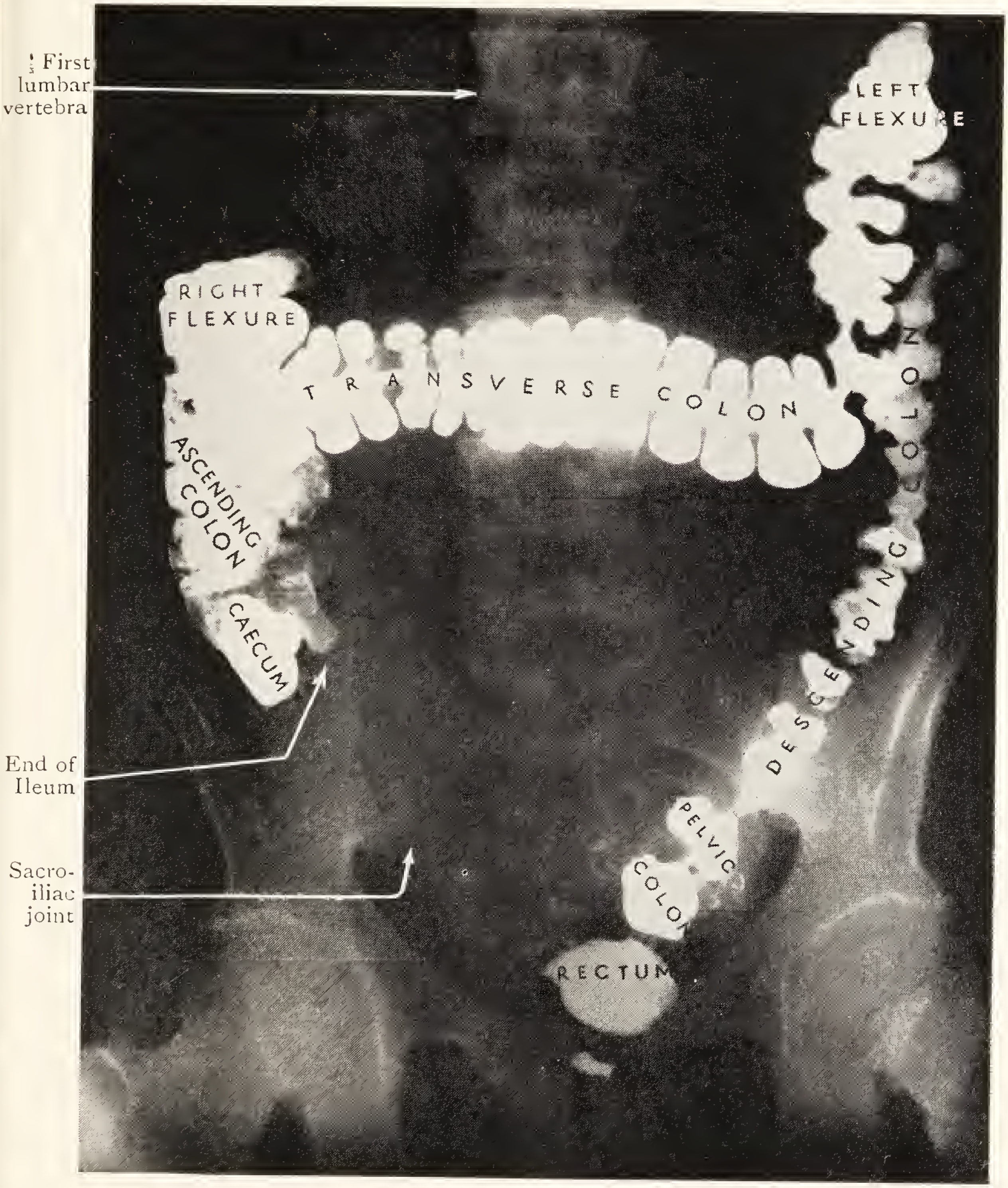

FIG. 162.—Radiograph of Large Intestine of man aged 31, taken 24 hours after a barium meal.

(Dr. J. F. Brailsford)

Note the high position of the Cæcum (Cf. Fig. 140), and that the Pelvic Colon appears very short, as it contains very little barium.

[*Facing p.* 320

PLATE XVIII

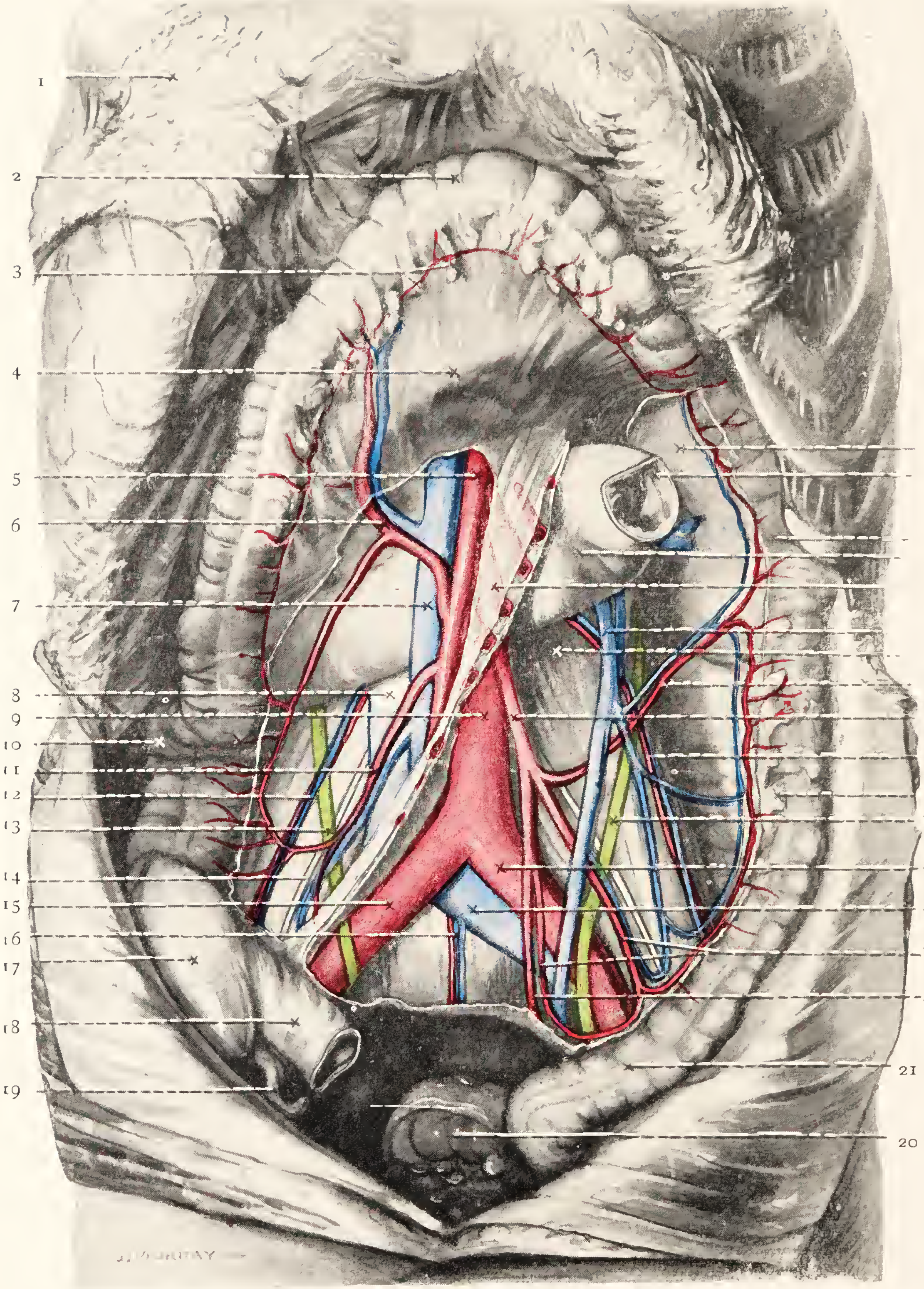

FIG. 163.—Structures on lower part of Posterior Wall of Abdomen. Compare with Figs. 128, 129 and 172.

[*Facing p.* 321

large extent been examined already. It stretches upwards and backwards from the transverse colon to the lower border of the pancreas. It is supported posteriorly by the coils of the jejunum, and is separated from the stomach anteriorly by the cavity of the lesser sac. Between its layers, it contains (besides a certain amount of extra-peritoneal fatty tissue) the vessels and nerves that supply the transverse colon :—(1) The middle colic vessels and their branches and tributaries. (2) The uppermost branches of the left colic vessels. (3) Nerves accompanying the arteries. (4) Lymph-vessels, which end in glands that lie alongside the blood-vessels.

Left Flexure of Colon.—The left flexure is a sharper bend than the right ; it reaches a slightly higher level, and is also a little farther from the median plane (Figs. 162, 163). It lies on the diaphragm opposite the eleventh rib, at the lateral border of the left kidney, immediately below the spleen, and behind the stomach or the left margin of the greater omentum. The fold of peritoneum, called the *phrenico-colic ligament*, which is pinched up in the groove on its lateral side, connects it with the diaphragm ; and it is further attached to the diaphragm and the kidney by the peritoneum which covers its front and sides (leaving its posterior surface bare). But it may be enclosed in peritoneum and connected with the end of the

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FIG. 163.—The greater omentum and the transverse colon have been turned upwards, the small intestine has been removed, and the structures on the posterior wall up to the transverse mesocolon have been exposed by dissection.

1. Greater omentum.
2. Transverse colon.
3. Appendices epiploicæ.
4. Transverse mesocolon.
5. Superior mesenteric artery.
6. Middle colic artery.
7. Superior mesenteric vein.
8. Inferior vena cava.
9. Aorta.
10. Right flexure of colon.
11. Common trunk of right colic and ileo-colic arteries.
12. Testicular vessels.
13. Ureter.
14. Genito-femoral nerve.
15. Right common iliac artery.
16. Median sacral vessels.
17. Cæcum.
18. Ileum.
19. Vermiform appendix.
20. Pelvic colon.
21. Junction of descending and pelvic colon.
22. Superior rectal artery.
23. Inferior left colic arteries.
24. Left common iliac vein.
25. Left common iliac artery.
26. Ureter.
27. Descending colon.
28. Testicular vessels.
29. Inferior mesenteric artery.
30. Superior left colic artery.
31. Psoas major muscle.
32. Inferior mesenteric vein.
33. Root of mesentery.
34. Duodeno-jejunal flexure.
35. Left flexure of colon.
36. Jejunum.
37. Left kidney.

pancreas by the attenuated left end of the transverse mesocolon and to the stomach by the uppermost part of the left margin of the greater omentum. It will then enjoy more movement. Radiographs indicate that in the living it is sometimes fairly movable.

Vessels and Nerves of Transverse Colon and Left Flexure.—The main blood-supply of the transverse colon is from the middle colic vessels, but the right end is partly supplied from the upper branch of the right colic, and left end from the upper branch of the left colic, which supplies the left flexure also. The lymph-vessels end in glands in the mesocolon. The nerves are filaments that accompany the arteries; most of them are sympathetic fibres, but a few come from the vagi.

Descending Colon.—This part of the colon includes what was formerly called the iliac colon as well as the part named the descending colon. It extends from the spleen to the left side of the brim of the true pelvis, and is from nine to twelve inches long. It begins at the left flexure and runs downwards, first with a curve along the lateral margin of the left kidney and then straight to the iliac crest and onwards in the iliac fossa to the medial side of the anterior superior spine; it then runs medially with a curve, a very little distance above the inguinal ligament, to reach the pelvic brim, where it ends by becoming the pelvic colon.

Relations.—The peritoneum covers its front and sides and binds it to the posterior wall; but as it is usually empty and shrunken, less of its posterior wall is bare than is the case in the ascending colon.

As its ends are respectively higher and lower than those of the ascending colon, it is related to a larger number of structures. Unless it is unusually distended, coils of the small intestine and the greater omentum intervene between it and the *anterior* and *lateral* walls of the abdomen. *Medially*, it is related to the left kidney and psoas major and to coils of intestine. *Posteriorly*, it is closely related, in succession, to the diaphragm, the transversus abdominis, the quadratus lumborum, the iliacus and the psoas major, and also to a number of vessels and nerves that intervene between it and some of those muscles, viz.:—the ilio-hypogastric and ilio-inguinal nerves, on the quadratus; the lateral cutaneous nerve of the thigh and iliac branches of the ilio-lumbar vessels, on the iliacus; the femoral nerve, between the iliacus and psoas; the external iliac vessels, on the psoas; the testicular (or ovarian) vessels and the branches of the genito-femoral nerve, in close relation to the external iliac artery.

The relationship to the testicular and external iliac veins should be specially noted, for the weight of a loaded pelvic colon dragging on the end of the descending colon and causing it to exert greater pressure on those veins accounts for the fact that varicosity of the veins is more common in the left spermatic cord and left leg than in the right.

Vessels and Nerves.—The descending colon is supplied by the left colic vessels and nerves. Its lymph-vessels end in glands alongside its blood-vessels.

Dissection.—**Incise the peritoneum along the lateral margin of the descending colon, and turn the colon medially out of the way; and then clean and examine the structures that form its posterior relations.**

Pelvic Colon.—The pelvic colon has an average length of about fifteen inches, but varies from five to thirty-five inches. It begins at the lower part of the left side of the brim of the pelvis, where it is continuous with the descending colon; it ends on the pelvic surface of the middle piece of the sacrum, where it is continuous with the rectum. Being suspended by a mesocolon, it is movable and may lie anywhere consistent with its own length and the length of its mesocolon—even high up in the abdomen proper—but usually it lies in the pelvis under the coils of the ileum. Its position in the pelvis varies with its own length and degree of distension and with the degree of distension of the pelvic viscera; but a common course taken by an empty pelvic colon of average length is—first backwards on the left side of the pelvis, then across to the right side, passing above the bladder in the male and above the uterus in the female, and then towards the left and backwards again to reach the middle of the sacrum.

Vessels and Nerves.—The pelvic colon is supplied by the lower left colic vessels and nerves. Its lymph-vessels end in glands that lie in the mesocolon.

Pelvic Mesocolon.—The pelvic mesocolon is very variable in its extent. Lift the pelvic colon out of the pelvis and examine the attachments of the mesocolon. If the mesocolon is of ordinary dimensions, the attachment begins at the end of the descending colon on the left external iliac vein, runs upwards along the iliac arteries to the middle of the common iliac (where the superior rectal artery begins), and then downwards and medially across the left common iliac vein to the sacrum to end at the beginning of the rectum. The attachment is therefore like an inverted V placed obliquely. The superior rectal (hæmorrhoidal) artery runs in the medial limb of the Λ to reach the rectum; the branches of the lower left colic vessels enter the mesocolon through the lateral limb.

The mesocolon encloses the gut in its free border; it contains also some extraperitoneal fatty tissue and the blood-vessels, lymph-vessels, lymph-glands and nerves associated with the pelvic colon.

Tæniæ Coli.—These are the three longitudinal bands that constitute the longitudinal muscular fibres of the colon, and are placed at nearly equal distances apart. They are shorter than the potential length of the colon by one-sixth, and therefore pucker up the colon into three rows of pouches called *sacculations*. They begin at the root of the vermiform appendix, with whose longitudinal fibres they are continuous. Diverging from one another at first, they run along the whole length of the colon, and at the lower part of the pelvic colon they spread out sideways and unite with one another to form a complete longitudinal layer in the wall of the rectum.

On the ascending and descending colon, one tænia is anterior and two are posterior, but on the transverse colon in its natural position the anterior band becomes posterior (the continuity being seen if its surfaces are reversed, as they are when it is thrown upwards over the ribs), the postero-lateral band runs along the attachment of the greater omentum, and the postero-medial along the mesocolon.

Lymph-Glands of Large Intestine.—Small glands are present on the walls of all parts of the colon along its concave border, and also alongside the blood-vessels that supply the large intestine. The lymph from the cæcum, vermiform appendix, ascending colon and transverse colon is carried by the lymph-vessels through those two groups of glands, and onwards to the glands in the root of the mesentery, whence it passes into the intestinal lymph-trunk. The lymph from the descending colon and pelvic colon passes through corresponding glands to aortic glands along the left side of the aorta, whence it is carried by the left lumbar lymph-trunk (p. 386) to the cisterna chyli. (Fig. 194).

The lymph-glands that receive the lymph of the rectum and anal canal are described with the pelvis.

The cæcum and the greater part of the colon have now to be removed.

Dissection.—Place two ligatures round the upper part of the ascending colon, divide the gut between them, and remove the cæcum and ascending colon. Place two ligatures round the transverse colon about two inches from the right flexure, and another two at the same distance from the left flexure, divide the gut between the two ligatures at each end, and cut the transverse colon away from its mesocolon. In like manner, ligature the descending colon near its ends, divide it and remove it.

Take the portions of the gut to the sink, remove the ligatures, wash out their cavities with running water, and slit them up.

Structure of Large Intestine.—Like the small intestine, the large intestine has four coats—serous, muscular, submucous and mucous.

The **serous coat** is the peritoneal covering, and is closely bound to the muscular coat by a very thin layer of extraperitoneal tissue; and it is thinner than the peritoneum of the adjoining folds and parietes.

It is complete on the cæcum, and also on the vermiform appendix, transverse colon and pelvic colon, except along the lines where their peritoneal folds are attached to them. It is incomplete on the ascending colon and descending colon and upper part of rectum, for their posterior surfaces are in direct relation with the parietes. And the lower third of the rectum and the anal canal have no serous coat at all, for they are below the level reached by the peritoneum in the pelvis.

The special characteristic of the serous coat of the colon is the presence of the *appendices epiploicæ.* They are numerous little narrow pockets of peritoneum filled with fat that project from the surface of all parts of the colon, but they are absent from the cæcum, appendix and rectum; they are most numerous and obvious on the posterior surface of the transverse colon and on each side of the upper part of the pelvic colon.

The **muscular coat** is composed of non-striped muscle, and, as in the small intestine, it is in two layers—outer and inner. In the *outer layer,* the fibres are arranged longitudinally, and it is complete in the vermiform appendix, the rectum and the anal canal; in the other parts it is arranged in three separate bands called the tæniæ coli, which have been described already. The *inner layer* is a complete layer of circular fibres. In the colon it is thickest between the sacculations; and in the anal canal it is greatly thickened to form the *internal sphincter ani.*

The **submucous coat** is a loose layer of areolar tissue which binds the muscular and mucous coats together; it contains networks of the blood-vessels and lymph-vessels and nerves that supply the mucous coat.

The **mucous coat** consists of:—(1) multitudes of tubular *intestinal glands* placed side by side and held together by very delicate areolar tissue; (2) a thin layer of non-striped muscle—*lamina muscularis mucosæ*—which separates the glands from the submucous coat; (3) numerous *solitary lymphatic nodules,* placed at intervals between the glands, bulging on to the surface, and bulging the muscularis mucosæ into the submucous coat. Hold a piece of gut against the light and stretch it ; note the little opacities made by the solitary lymphatic nodules ; note also that there are no aggregated nodules. Examine the surface with a pocket-lens, and note that there are no villi.

The mucous coat is much more extensive than the muscular coat. It is therefore thrown into numerous crescentic folds which are arranged transversely opposite the grooves between the sacculations and obliquely between the grooves.

Structure of Vermiform Appendix.—The appendix differs in structure (as well as in girth) from the main part of the large intestine in some important respects. The serous coat is complete except along the attachment of its mesentery, and appendices epiploicæ are either absent or very small. The outer and inner layers of the muscular coat are both complete. The outstanding feature in the structure is the size and number of the lymphatic nodules, which are placed close together, forming a complete layer that makes up the greater part of the thickness of the appendix. They bulge outwards, obliterating the submucous coat, and inwards, almost obliterating the lumen and reducing the mucous coat to a thin membrane evaginated here and there to form small tubular glands. These nodules swell greatly when the appendix is inflamed, till the appendix is as thick as a finger.

The rectum and anal canal will be examined when the pelvis is dissected. The dissectors will now return to the first part of the small intestine—the duodenum—whose complete examination was deferred because its dissection (in its proper sequence, after the stomach) would have interfered too much with the relations of the other portions of the intestines.

Dissection.—**Remove the remains of the transverse mesocolon from the pancreas ; complete the cleaning of the pancreas ; and trace the duodenum from its beginning at the pylorus to its end in the duodeno-jejunal flexure.**

Duodenum.—The duodenum is the first and shortest part of the small intestine, being only about ten inches in length. It is the widest and most fixed of the three parts of the small intestine, and its walls are thicker than those of the other two parts. It extends from the pylorus to the duodeno-jejunal flexure, describing a C-shaped curve whose concavity is directed towards the left and upwards and is occupied by the head of the pancreas. Owing to the C-shape of its curve, its beginning and end are not far apart. It lies on the posterior wall of the abdomen above the level of the umbilicus, and almost wholly in the right half of the abdomen. All its parts do not lie in the same plane, for it is moulded on the right side and the front of the median longitudinal elevation made by the vertebral column and psoas muscles. The descending portion or right part of the C is thus much farther back than the rest of it (Fig. 172). The principal changes of direction in the C-shaped curve are made use of to divide it into four parts for convenience of description.

Relations.—The **first part** is two inches long. It begins at the pylorus, in the transpyloric plane, about an inch to the right of the median plane, and passes sidewards and backwards and slightly upwards in close relation with the liver, and ends at the neck of the gall-bladder by bending sharply to become the second part ; here, it is usually stained green after death by bile that soaks through the walls of the gall-bladder. The first inch is clothed on the front and the back with the peritoneum continued on to it from the stomach. This portion is connected therefore with the omenta above and below ; and, posteriorly, it is separated by the lesser sac of peritoneum from the neck of the pancreas ; anteriorly, it is related to the quadrate lobe of the liver. The second inch is clothed with peritoneum only above and in front, where it is related to the liver and the neck of the gall-bladder. Inferiorly, it is related directly to the head of the pancreas. Posteriorly, it is directly related to the gastro-duodenal artery, the bile-duct, the portal vein and a small portion of the neck of the pancreas ; and these structures separate it from the inferior vena cava. It should be noted that, owing to its backward direction, these structures are medial to it rather than behind it.

The first inch, owing to its peritoneal connexions, is free to move, and moves with the stomach. The second inch, like the other parts of the duodenum, is fairly firmly fixed by areolar tissue to the structures behind it.

The **second part** is three inches long. It descends to the level of the third lumbar vertebra and then bends at a right angle to become the third part. Anteriorly, it is crossed by the first part of the transverse colon, which covers most of it, and is overhung by the liver and the gall-bladder ; above the transverse colon, it is more directly related to the liver and the gall-bladder ; and its lowest part is covered by a loop of the jejunum, and may be crossed by the ascending branch of the right colic artery. Posteriorly, it rests on the medial part of the right kidney and on the psoas major, being partly separated from the muscle by the renal vessels and the ureter. Laterally, it is related merely to the fat on the kidney. Medially, it is closely applied to the head of the pancreas. The bile-duct and the pancreatic duct enter it together on its postero-medial surface a little below its middle.

The second part of the duodenum has a very incomplete covering of peritoneum—only on the parts of the anterior surface that are above and below the transverse colon, for the colon lifts the peritoneum off the greater part of it.

The **third part** is nearly four inches long. It begins on the right psoas major at the level of the third lumbar vertebra and passes nearly horizontally towards the left across the inferior vena cava and the aorta, and then bends upwards to become the fourth part. The anterior and inferior surfaces are clothed with peritoneum except at its end where it is crossed by the superior mesenteric vessels and the root of the mesentery. On the right side of the mesentery it is covered by loops of the jejunum, which separate it from the transverse colon. Superiorly, it is closely applied to the head of the pancreas. Posteriorly, it rests on the right psoas, the inferior vena cava and the aorta, with certain smaller structures intervening, namely—the ureter, on the psoas; the testicular (or ovarian) artery, on the vena cava; and the inferior mesenteric artery, springing from the aorta.

The **fourth part** is the shortest part—little more than an inch in length. It curves upwards along the left side of the aorta and the head of the pancreas on to the left psoas muscle, and ends about an inch to the left of the median plane, at the level of the second lumbar vertebra, by bending sharply forwards to form the duodeno-jejunal flexure, where it is continuous with the jejunum. On the front and the left side it is covered with peritoneum and related to the jejunum. Behind, it is related to the backbone, the left sympathetic trunk, testicular (or ovarian) artery and psoas major.

Variations in Form and Position.—The curve of the duodenum varies with the position of the third part. Usually the third part is nearly horizontal and the fourth part nearly vertical (Fig. 137); but the third part may incline upwards as it passes towards the left, and lie in line with the fourth part (Fig. 138).

There are, in addition, considerable variations not only in the position of the first part owing to its mobility (Figs. 140, 141) but also in the position of the whole duodenum in relation to the vertebral column; and these, like the different types of stomach, seem to be associated with the body-build or habitus (Figs. 137, 138).

Vessels and Nerves of Duodenum.—The *arteries* are small branches from the hepatic, the right gastric, the pancreatico-duodenal and the right colic. The *nerves* are derived from the cœliac and superior mesenteric plexuses, and accompany the arteries. The *lymph-vessels* end in glands that lie between the duodenum and the head of the pancreas, whence the lymph is carried to glands near the origins of the cœliac and superior mesenteric arteries.

Dissection.—Detach the transverse colon from the duodenum and displace it towards the right. Now, incise the peritoneum along the right margin of the second part of the duodenum, and the lower and left margins of the third and fourth parts ; raise the duodenum carefully, fold it over on to the front of the pancreas, and fix it with pins ; then, dissect out the structures that lie behind the various parts of the duodenum.

When that has been done, replace the duodenum, pull the duodeno-jejunal flexure gently downwards, push the pancreas upwards, and expose some fatty tissue between them. Explore that fat with the point of the forceps. The inferior mesenteric vein will probably be found in it, and, sometimes, the lower border of the left renal vein. Push the veins aside, and look in the fat behind them for a slender fibro-muscular bundle called the *suspensory muscle of the duodenum.*

Suspensory Muscle of Duodenum.—This is a muscular band that prevents the duodeno-jejunal flexure from being dragged downwards by the weight of the jejunum and ileum. It springs from the right crus of the diaphragm on both sides of the œsophageal opening (Fig. 190), descends over the left crus behind the cœliac plexus, the splenic and left renal veins and the pancreas, and is inserted into the duodeno-jejunal flexure. In the child, the muscle is well-marked and easily isolated, and some of its fibres can be traced into the root of the mesentery, where they are inserted into the peritoneum. In the adult, it becomes ligamentous and loose ; and it is difficult to distinguish it from the surrounding fibrous tissue.

The dissectors must now study the structure of the duodenum and examine its interior. If the liver is large and unyielding, the dissection may have to be deferred till the duodenum is removed from the body, when it can be more easily manipulated ; but the attempt should be made now.

Dissection.—A window was made in the first part of the duodenum when the pylorus was examined. Now, lay open the whole of the duodenum by a cut near its convex margin, and sponge out the interior.

Structure of Duodenum.—Like the other parts of the intestine, the duodenum has four coats.

It was noted when the relations were studied, that the **serous coat** of peritoneum was incomplete.

The **muscular coat** is disposed in an *outer layer* of longitudinal fibres and an *inner layer* of circular fibres—as in other parts of the intestine.

The **submucous coat** is peculiar in that it contains small compound glands called the *duodenal glands*. These glands form an almost continuous layer in the upper half of the duodenum, and diminish progressively in the lower half. After the duodenum is removed from the body, a piece of the first part may be pinned down in the cork-lined tray under water with the mucous surface downwards. If the serous and muscular coats are carefully removed, the duodenal glands will be seen as small reddish-grey bodies about the size of hemp seed. Their ducts pierce the lamina muscularis mucosæ and pass between the *intestinal glands* of the mucous coat to open on the mucous surface.

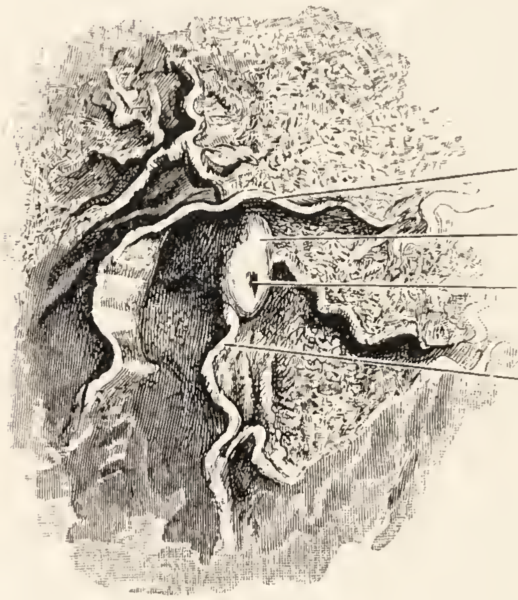

FIG. 164.—Duodenal Papilla, at the upper end of longitudinal fold. (Birmingham)

The **mucous coat** resembles that of the jejunum. Note, however, that it is stained green with bile; and a pocket-lens will show that its *intestinal villi* are short and broad.

The *circular folds* begin about an inch from the pylorus, and are at first small and irregular, but become large and numerous lower down. Look on the lower half of the second part near its postero-medial border for a *longitudinal fold* of the mucous coat that runs sinuously between and across the circular folds. Trace it upwards. It leads to a small round eminence called the *duodenal papilla*, which may be quite obvious or may be hidden under a circular fold that overlaps it like a hood. On the summit of the papilla there is a small aperture which is the common opening of the bile-duct and the pancreatic duct. Usually, the papilla is at the upper end of the longitudinal fold, which is a guide to it if it is hidden. But it may be on the middle of the fold; or it may be absent, in which case the common opening of the ducts is in a recess at the side of the upper part of the fold (Figs. 166, 167).

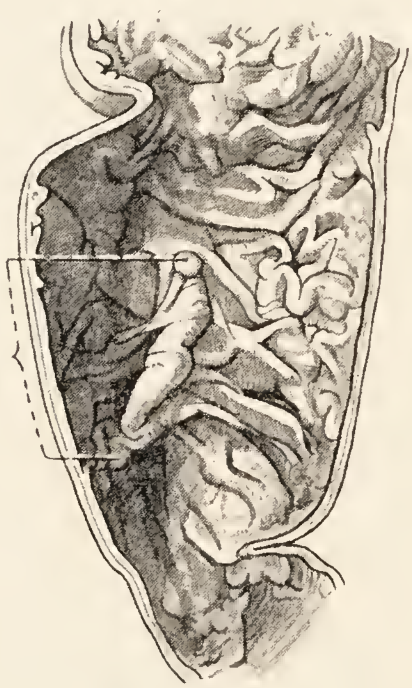

FIG. 165.—Duodenal Papilla, at the upper end of longitudinal fold under a hood-like circular fold.

Look now a little higher up and farther forwards on the mucous wall for an occasional, smaller papilla on which the accessory duct of the pancreas opens.

The bile-duct and the portal vein were cleaned in a great part of their extent when the lesser omentum was dissected, and a further portion when the first part of the duodenum was studied. The dissectors will now proceed to clean their remaining portions, to define the subdivisions of the pancreas, and to expose and clean the splenic vein — beginning with that vein.

FIG. 166.—Duodenal Papilla, at the middle of longitudinal fold.

Dissection.—Disengage the left end of the *body of the pancreas* from the spleen, lift up the body carefully, find the *splenic vein* (which runs lengthwise behind it), trace the vein from the spleen to its junction with the *superior mesenteric vein* ; and trace the upper part of the *inferior mesenteric vein* to its termination. Clean the structures that lie on the back wall behind the splenic vein and the body of the pancreas.

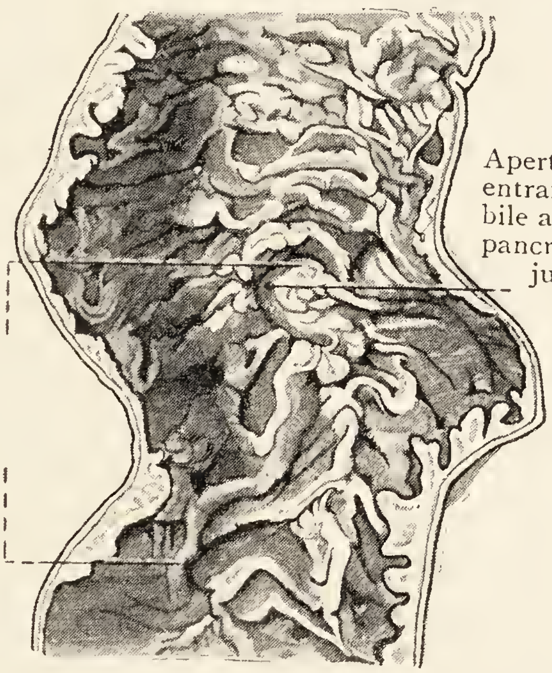

FIG. 167.—Duodenal Papilla is absent. Opening of ducts is on the upper part of posterior face of longitudinal fold.

The upper parts of the superior mesenteric vessels lie on a part of the head of the pancreas called its *uncinate process*. Lift the vessels up from the process, clean the vessels, follow the process upwards behind them, and define its left and upper margins. Then, raise the third part of the duodenum and the uncinate process, and free the process from the structures behind it.

Next, lever up the neck of the pancreas, first from below and then from above, and clean the portion of the portal vein that lies behind it.

Portal Vein.—The portal vein is a wide vein about two inches long. By means of its tributaries, it drains the blood from the spleen, the pancreas and the gall-bladder, and from all the abdominal part of the alimentary canal except the lower part of the rectum and the anal canal; and it pours its blood into the liver. It is peculiar among veins in that it begins like other veins by the union of tributaries, but ends like an artery by dividing into branches. It collects products of the digestion of carbohydrates and proteins from the intestines, and conveys them to the liver. In addition to this important function, the whole portal system acts as a reservoir of blood for the needs of the general circulation. It has been calculated that the portal system can contain about one-third of the total amount of blood in the body—the same proportion that passes through the liver every minute. The amount of blood can be increased or diminished by physiological variations in the width of the arteries by which it enters the system and of the terminal portions of the hepatic veins, by which it leaves it. The spleen may be regarded as a specialised portion of the portal reservoir.

Valves are absent from the portal vein and its large tributaries, but are present in some of its smaller tributaries, notably the gastric veins.

Origin, Course and Termination.—The portal vein begins behind the neck of the pancreas, in front of the inferior vena cava, by the union of the splenic and superior mesenteric veins. From that point of origin, it ascends behind the first part of the duodenum to enter the lesser omentum; it passes upwards in the free margin of the lesser omentum to the right part of the porta hepatis, where it ends by dividing into a right and a left branch.

Relations.—While it is behind (and medial to) the first part of the duodenum, the bile-duct and the gastro-duodenal artery lie between it and the duodenum, and it is in front of the vena cava. While in the lesser omentum, it is still in front of the vena cava, but is separated by the opening into the lesser sac; and its anterior relations are the bile-duct again and the hepatic artery. In the porta, its branches are behind the branches of the hepatic artery and the hepatic ducts.

Tributaries.—Its direct tributaries are few:—The splenic and superior mesenteric veins form it; a pancreatico-duodenal vein joins it behind the duodenum; the right and left gastric veins join it immediately before it enters the lesser omentum ; and the cystic vein from the gall-bladder joins its right branch.

Branches of Portal Vein.—The *right branch* of the portal vein receives the cystic vein, and then sinks into the right lobe

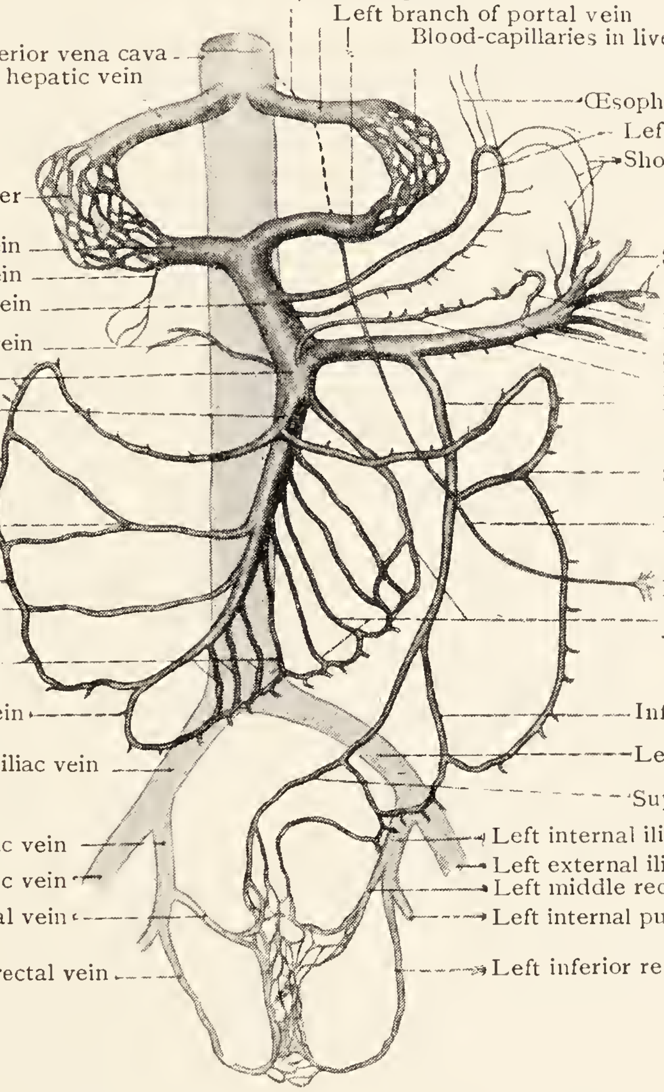

FIG. 168.—Schema of Portal System of Veins and its Connexions with Systemic Veins. It must be remembered that the systemic blood carried by the hepatic artery also enters the capillaries of the liver, and the hepatic veins contain therefore both portal and systemic blood.

of the liver. The *left branch*—narrower and longer—runs to the left end of the porta to sink into the left lobe. The distribution of these branches in the liver will be examined later.

Communications.—At the left end of the porta, the left branch is joined by the ligamentum venosum from behind and by the ligamentum teres from in front. Some small veins, called *para-umbilical veins*, run along the round ligament and connect the left branch with the superficial veins around the umbilicus; when there is obstruction to the flow of blood through the liver, the para-umbilical veins enlarge and drain off some of the blood into enlarged superficial veins which radiate from the umbilicus. Other communications are established with systemic veins by some of the outlying veins of the portal system—notably, at the lower end of the œsophagus by the left gastric vein (p. 282), and in the pelvis by the superior rectal vein (p. 442).

Splenic Vein.—The splenic vein has farther to go than its artery, for it has to cross the median plane to reach the beginning of the portal vein; and it is a little lower than the artery, for it is behind the pancreas; the artery begins in the median plane and runs along the upper border of the pancreas.

Origin, Relations and Termination.—The vein begins in the lieno-renal ligament by the union of five or six veins that issue from the hilum of the spleen. It emerges from the ligament and runs towards the right behind the body of the pancreas across the left kidney, the left psoas and sympathetic trunk, the left crus of the diaphragm and the aorta, to end on the front of the inferior vena cava by joining the superior mesenteric vein to form the portal vein. It crosses the aorta between the origins of the cœliac and superior mesenteric arteries, and is closely related to both of them—the cœliac above it, the superior mesenteric below it.

Tributaries.—Besides its *splenic* tributaries, the *short gastric* and *left gastro-epiploic* veins from the stomach join it near its origin or may join these tributaries; small *pancreatic* veins join it throughout its course; and the *inferior mesenteric*, bringing blood from the rectum and the distal half of the colon, joins it at any part of its last two inches—and may even join the commencement of the portal vein or the end of the superior mesenteric.

Dissection.—Now, turn to the second part of the duodenum. Fold it over on to the front of the head of the pancreas, and carefully raise the head from the structures behind it, bending it over towards the left; examine the back of it for a *pancreatico-duodenal vein* and the *bile-duct.* The vein is on the surface on the medial side of the bile-duct, and is ascending to the portal vein. Find the bile-duct above the pancreas, trace it downwards, through a groove in the back of the head of the pancreas, to

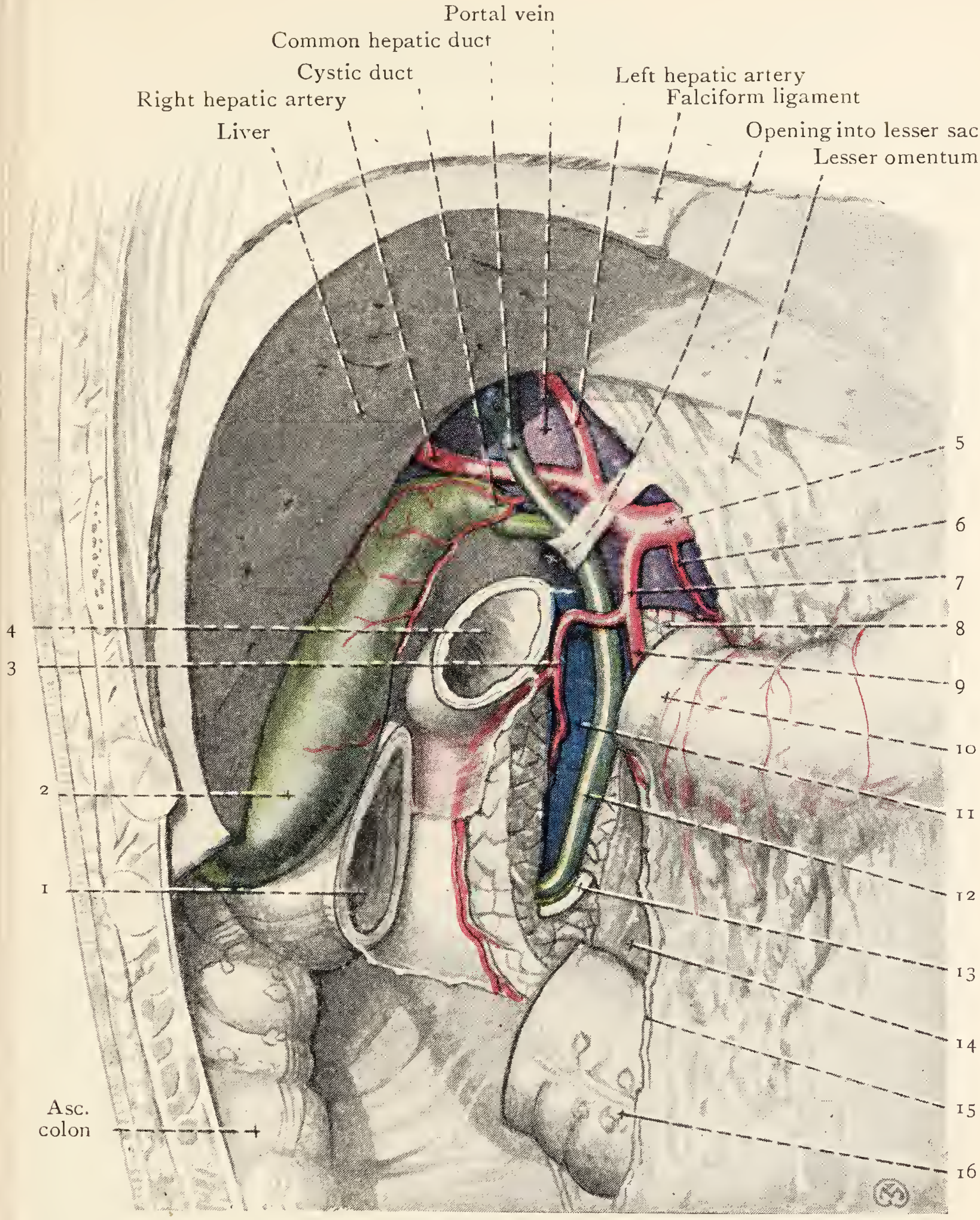

FIG. 169.—Dissection showing Hepatic Ducts and Bile-Duct and their relations.

1. Transverse colon.
2. Gall-bladder.
3. Superior pancreatico-duodenal artery.
4. Duodenum (first part).
5. Hepatic artery.
6. Right gastric artery.
7. Gastro-duodenal artery.
8. Neck of pancreas.
9. Right gastro-epiploic artery.
10. Pylorus.
11. Inferior vena cava.
12. Bile-duct.
13. Pancreatic duct.
14. Transverse mesocolon.
15. Cut edge of greater omentum.
16. Transverse colon.

the duodenum ; close to its end, find its junction with the pancreatic duct.

Finally, clean the structures behind the head of the pancreas.

Ducts of the Liver.—The bile, secreted by the cells of the liver, is carried away from the liver-lobules by slender tubes called the *bile-ductules*. The ductules end in wider tubes called the *interlobular ducts*. They unite to form a *right* and a *left hepatic duct*, which issue from the right and left lobes into the porta hepatis and join each other to form the *common hepatic duct*. The common duct unites with the *cystic duct*—*i.e.* the duct of the gall-bladder—to form the *bile-duct*, which ends in the duodenum. Bile flows in only one direction through the hepatic ducts and bile-duct—towards the duodenum. Through the cystic duct, it flows sometimes to the gall-bladder and sometimes from it, for the gall-bladder is the reservoir in which the surplus gall or bile collects and is concentrated till it is required in the duodenum.

The *right* and *left hepatic ducts* unite in the porta, and are usually in front of the branches of the hepatic artery and portal vein. The *common hepatic duct* is nearly an inch long ; it passes downwards in front of the right branch of the hepatic artery, and joins the cystic duct outside the porta.

Bile-Duct (Ductus Choledochus).—The bile-duct is between three and four inches long and about a quarter of an inch wide. It begins near the porta hepatis by the union of the cystic duct and the common hepatic duct. It descends in the free margin of the lesser omentum and passes behind the first part of the duodenum to enter a groove in the back of the head of the pancreas in which it runs downwards and slightly to the right to end in the second part of the duodenum a little below its middle on its postero-medial surface.

Relations and Mode of Termination.—While the duct is in the lesser omentum, the portal vein is behind it, and the hepatic artery is medial to it. Behind the duodenum, the portal vein is still a posterior relation to the duct, but the artery on its medial side is now the gastro-duodenal. While the duct is in the head of the pancreas, the inferior vena cava is behind it, and the vessel on its medial side is a pancreatico-duodenal vein.

The duct penetrates the duodenal wall obliquely, and, as it does so, it expands to form a small dilatation called the *ampulla of the bile-duct*. The ampulla bulges the mucous

PLATE XIX

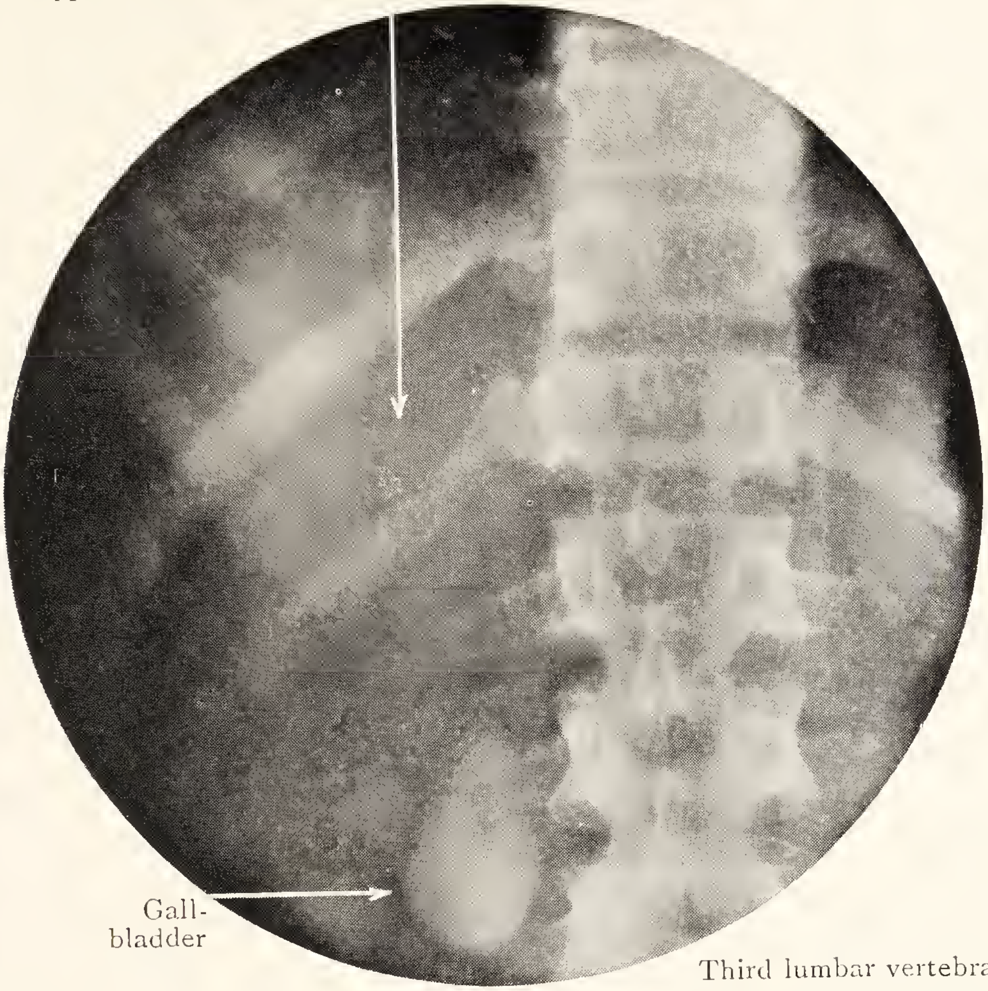

FIG. 170.—Radiograph showing average position of Gall-Bladder after administration of special radio-opaque substance excreted by the liver. (Dr. J. Duncan White)

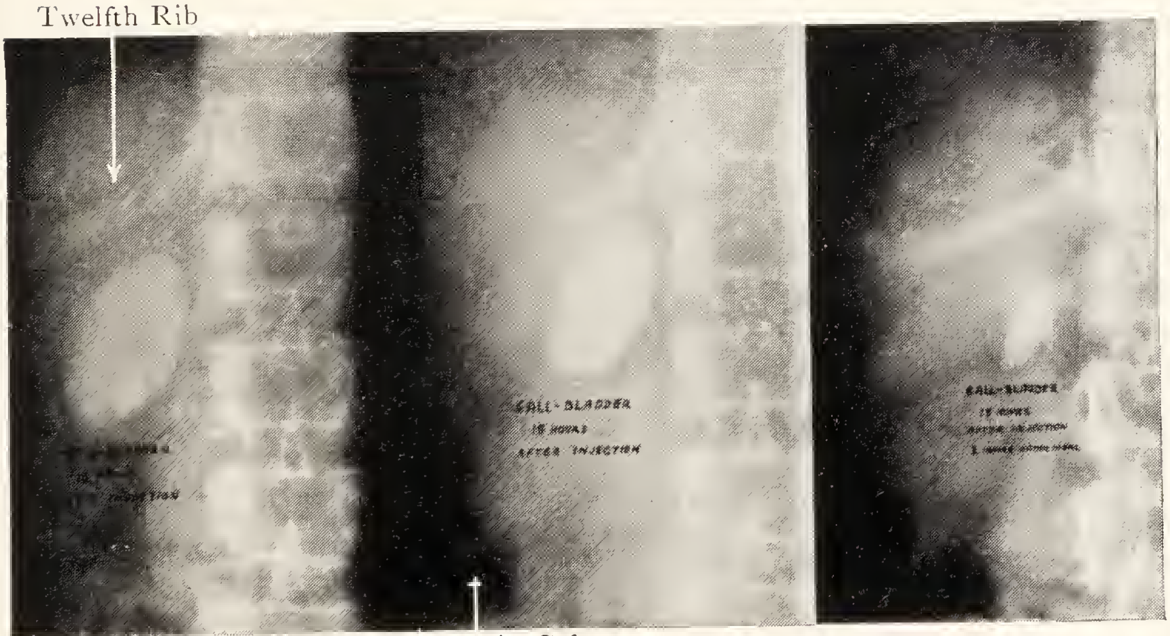

FIG. 171.—Serial Radiographs of the same Gall-Bladder showing physiological changes. (Dr. J. F. Brailsford)

A. 12 hours after intravenous administration of sodium tetra-iodo-phenol-phthalein.
B. 15 hours after ; concentration of bile.
C. 18 hours after ; 2 hours after meal ; discharge of bile into duodenum.

[*Facing p.* 336

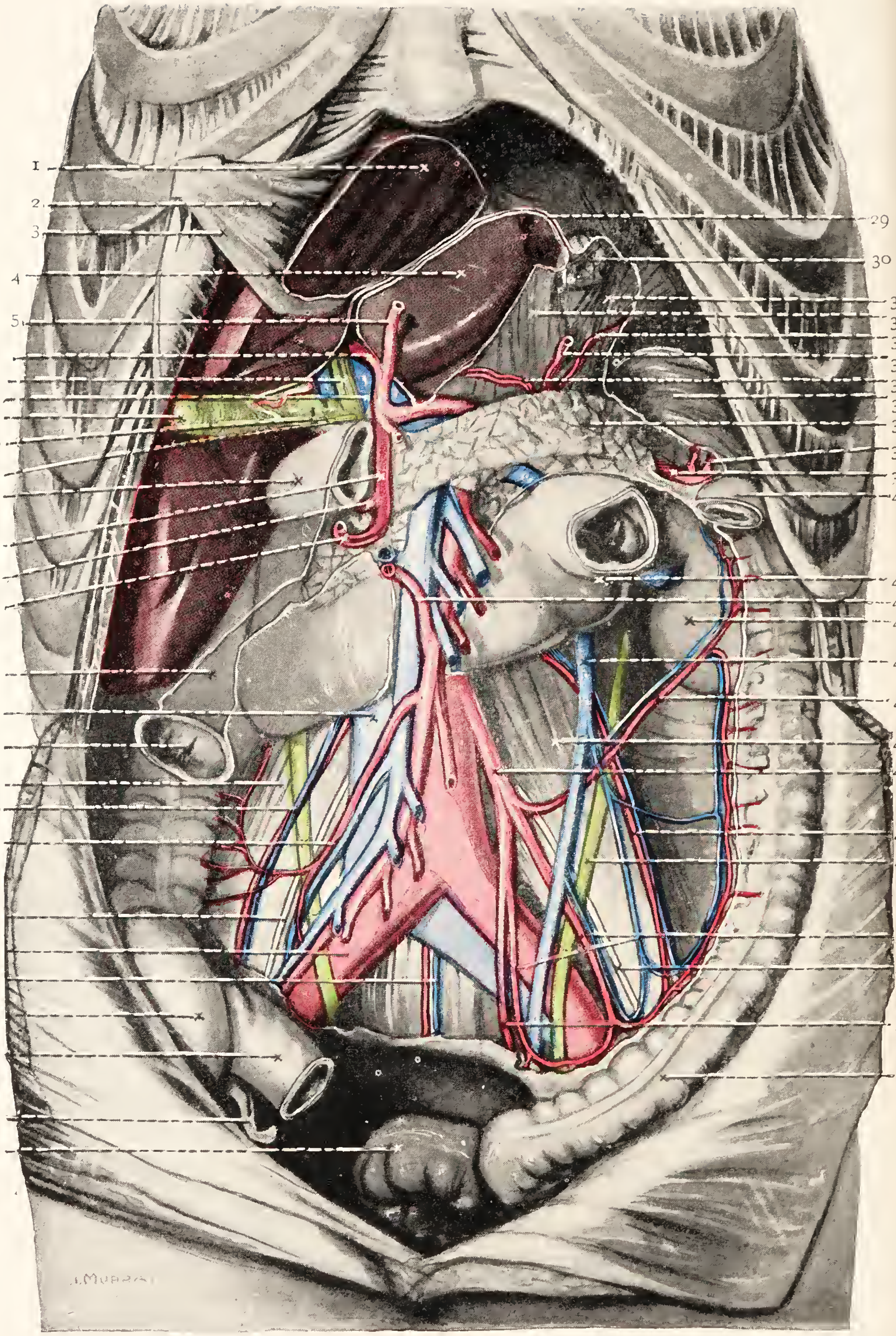

FIG. 172.—Structures on Posterior Wall of Abdomen. Compare with Figs. 128, 129 and 163.

[*Facing p.* 337

membrane inwards to form an elevation called the *duodenal papilla*, on whose summit the ampulla opens by a narrow orifice. Near the duodenum, the pancreatic duct approaches the bile-duct from the left, and, running alongside it, enters it either before or during the passage through the duodenal wall.

The dissectors will now proceed to study the characters and relations of the pancreas. The pancreas should be removed from the abdomen in order that its posterior relations may be seen, and that its ducts may be dissected. The spleen and the duodenum should be removed with the pancreas; and the three organs should be kept together, in order that they may be replaced from time to time when the relations of other organs are studied.

Dissection.—Cut the *splenic artery* about three-quarters of an inch from its origin. Divide the following structures:—(1) the *inferior mesenteric vein* at its entrance into the splenic vein; (2) the *gastro-duodenal artery*, the *bile-duct* and the *portal vein* at the upper border of the duodenum; (3) the *superior mesenteric artery* half an inch below its origin, and both the superior mesenteric artery and its vein at the lower border of the duodenum.

Pull the spleen towards the right, and tear or cut through the remains of the lieno-renal ligament; then, remove the spleen, pancreas and duodenum from the abdomen. Lay them aside in the meantime and complete the cleaning of the structures that lie behind the pancreas; and then identify the parts of the pancreas.

Pancreas.—The pancreas (the "sweetbread") is of great importance in the digestion and metabolism of food. It is a

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FIG. 172.—The dissections shown in Figs. 129 and 163 have been extended by the removal of the transverse colon, greater omentum and stomach to display the whole of the Duodenum, the Pancreas and the Spleen.

1. Cut surface of left lobe of liver.
2. Falciform ligament.
3. Ligamentum teres.
4. Caudate lobe.
5. Left hepatic artery.
6. Right hepatic artery.
7. Common hepatic duct.
8. Portal vein.
9. Gall-bladder.
10. Cystic duct.
11. Bile-duct.
12. Duodenum, first part.
13. Gastro-duodenal art.
14. Superior pancreatico-duodenal artery.
15. R. gastro-epiploic art.
16. Right kidney.
17. Inferior vena cava.
18. R. flexure of colon.
19. Psoas major muscle.
20. Testicular vessels crossing ureter.
21. Common trunk of R. colic and ileo-colic art.
22. Genito-femoral nerve.
23. R. common iliac art.
24. Median sacral vessels.
25. Cæcum.
26. Ileum.
27. Appendix.
28. Pelvic colon.
29. Cut edge of lesser omentum.
30. Œsophagus.
31. L. crus of diaphragm.
32. R. crus of diaphragm.
33. Left phrenic artery.
34. Left gastric artery.
35. Right phrenic artery.
36. Spleen.
37. Pancreas.
38. L. gastro-epiploic art.
39. Splenic artery.
40. L. flexure of colon.
41. Duodeno-jejunal flexure.
42. Middle colic artery.
43. Left kidney.
44. Inf. mesenteric vein.
45. Sup. left colic art.
46. Psoas major muscle.
47. Inf. mesenteric art.
48. Testicular vessels.
49. Ureter.
50. Inf. left colic arts.
51. Genito-femoral nerve.
52. Sup. rectal artery.
53. Lower part of descending colon.

yellowish, elongated gland that lies obliquely across the upper part of the posterior wall of the abdomen, extending from the second part of the duodenum to the spleen, partly enclosed in the concavity of the duodenum and partly behind the stomach, and rising slightly as it is traced from right to left.

It is very soft and pliable, as its lobules are held together by a minimum of areolar tissue; and its name *pancreas* signifies that there is no fibrous dross in it (*pan* = all; *creas* = flesh). Owing to its softness, it varies in form with the condition of the hollow organs near it; but, when it has been hardened *in situ*, four parts are usually recognisable—head, neck, body and tail, named in order from right to left.

Relations.—The **head** is the flattened and slightly expanded portion that occupies the concavity of the duodenum, whose second and third parts are usually overlapped by it.

Posteriorly, the largest structures related to the head are the aorta and the inferior vena cava. But there are other structures to be noted:—the terminal part of the left renal vein, and often that of the right; the uppermost parts of the testicular or ovarian arteries; the bile-duct, embedded in a groove in the back of the head near its lateral margin; and a pancreatico-duodenal vein along the medial side of the bile-duct.

Anteriorly, the largest structure in relation to it is the transverse colon, which covers the whole of it and may be in direct contact with it; but, if the mesocolon extends to the right as far as the front of the head, the colon will then be separated from the head by a portion of the lesser sac of peritoneum above the attachment of the mesocolon and a portion of the greater sac below. Further, the superior mesenteric vessels lie on the lower, left part of the head. This part is called the *uncinate process* because it extends upwards for some distance behind the neck and the right end of the body (from which it is separated by the mesenteric vessels) and gives the right part of the pancreas a fancied resemblance to a hook. (*Uncus* means a hook.)

The **neck** is an isthmus that unites the body to the upper part of the head. It is not always easy to decide where the neck ends and the other parts begin; but it may be defined as the part of the pancreas that lies in front of the ends of the splenic and superior mesenteric veins and the beginning of the portal vein. It is behind the pylorus and the beginning of the duodenum, from both of which it is separated by the lesser sac of peritoneum, except at the junction with the head, where it is separated from the duodenum by the gastro-duodenal artery.

The **body** of the pancreas extends to the left and backwards and slightly upwards behind the lesser sac. In its natural, soft condition, it is flattened from before backwards when adjoining organs are removed; but their pressure, while in place, moulds it into three distinct surfaces—anterior, posterior, and inferior—which it retains when it is hardened *in situ*.

The *anterior surface* is nearly all related to the stomach—forming a considerable part of the "stomach-bed". But in the median plane, a small portion adjoining its upper border rises above the level of the pyloric canal and bulges slightly forwards opposite the lesser omentum. This portion is called the *tuber omentale* of the pancreas; and the cœliac artery juts forwards immediately above it. From the cœliac, the splenic artery runs along the *upper border* of the anterior surface; and the *lower border* gives attachment to the transverse mesocolon.

The *inferior surface* is narrow. From right to left, it is related to the duodeno-jejunal flexure, a coil or two of the jejunum and the left part of the transverse colon; and it is separated from all three by peritoneum.

The *posterior surface* is related to a large number of structures. At its right end it is related to the aorta and the origin of the superior mesenteric artery, and then, from right to left, to the left crus, sympathetic trunk, psoas and kidney. Its upper part is separated from all these by the splenic vein, which runs from left to right behind the pancreas near its upper border, and is joined behind the pancreas by the inferior mesenteric vein; and, between the kidney and the aorta, the left renal vessels intervene between the pancreas and the posterior abdominal wall to a varying extent—being often partly seen below the pancreas. Smaller structures that may be mentioned are the left suprarenal vein, inferior suprarenal artery, and sometimes the lowest parts of the suprarenal gland and cœliac plexus.

The **tail** of the pancreas is merely the left end of the body, and is usually thick and blunt (Fig. 173). It is in relation to the spleen below the lateral part of its hilum (Fig. 131).

Vessels and Nerves of Pancreas.—The *arteries* are small branches from the splenic and pancreatico-duodenal arteries. The *nerves* accompany the arteries and are derived from the cœliac and superior mesenteric plexuses and the vagi. The *lymph-vessels* end in numerous glands that lie along its upper border (pancreatico-splenic glands), and in close relation to its head along the pancreatico-duodenal vessels.

Functions and Ducts of Pancreas.—The pancreas, like some other glands, manufactures two kinds of secretion—an *external*, drained away by the ducts, and an *internal*, which passes into the blood.

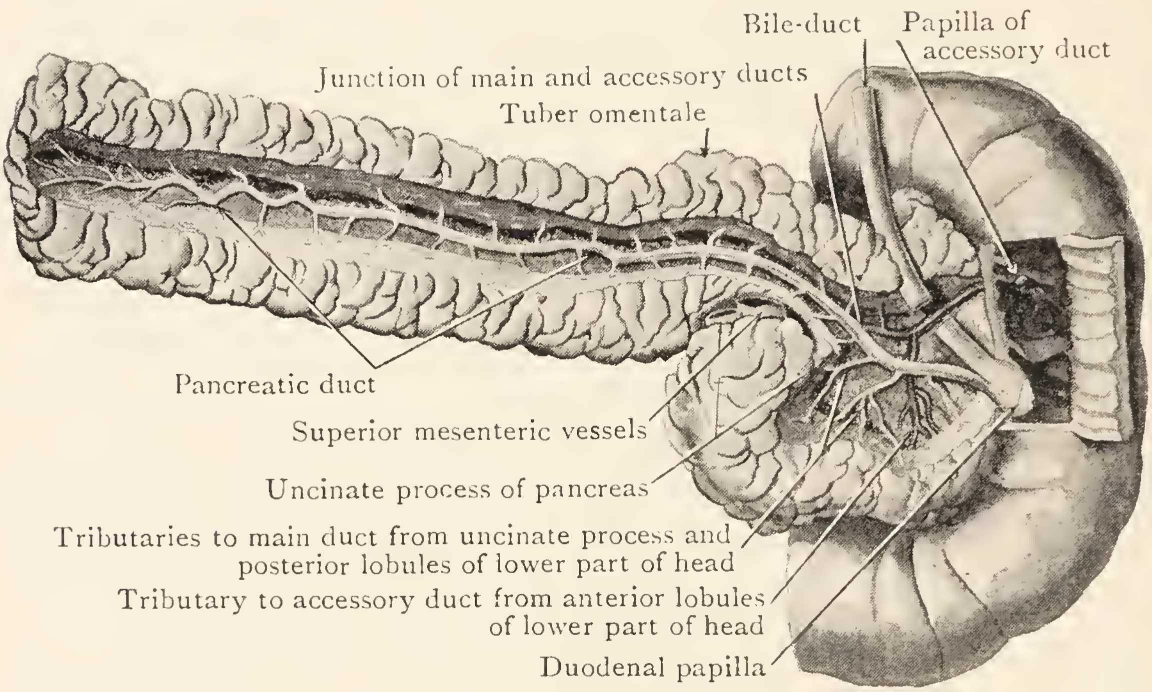

FIG. 173.—Dissection of Pancreas from behind to show its Ducts.

The internal secretion of the pancreas is a most important factor in the control of the amount of sugar in the blood. It has been named "insulin" because it is produced by certain parts of the pancreas known as the "islets" of Langerhans; these islets are not connected with the ducts, and they are too small to be demonstrated by dissection.

The external secretion is called the *pancreatic juice.* It is drained away by the pancreatic ducts, of which there are two—a principal and an accessory. They run nearly their whole course in the substance of the gland, and they open into the duodenum. The pancreatic juice, thus discharged into the intestines, is concerned with the digestion of all three of the principal forms of solid food—carbohydrates, fats and proteins.

The possession of two ducts, which open separately into the duodenum, is accounted for by the fact that the pancreas is developed from two rudiments which sprouted independently from the duodenum, and, though the glandular substance derived from them fused together into one mass, the ducts become connected with each other at only one point.

The principal *pancreatic duct* runs through the whole length of the gland, nearer the upper border than the lower, and rather nearer the front than the back, except near its termination. It begins at the tail by the union of two or

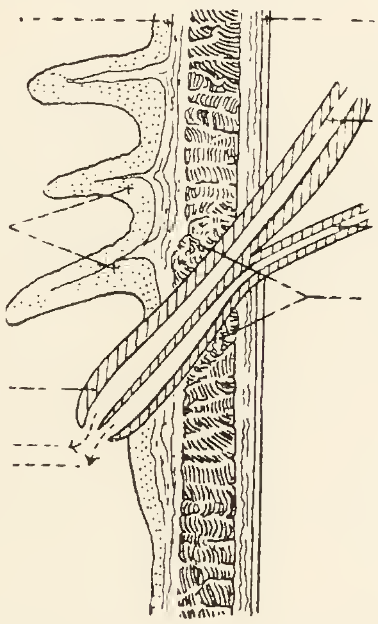

FIG. 174.—Diagrammatic Section of Wall of Duodenum through Papilla, showing a completely divided Ampulla.

three tributaries and runs through the body, gathering in short tributaries on the way. At the neck, it bends downwards into the head, where it receives tributaries from the uncinate process and the posterior lobules of the right part of the head. Finally, it approaches the bile-duct, runs along its medial side for a short distance, and then enters the bile-duct as it begins to pierce the duodenal wall.

Dissection.—**Find the orifice of the bile-duct on the duodenal papilla; pass a probe through it, first into the bile-duct and then into the pancreatic duct, and note the point at which the two ducts unite.**

The *accessory pancreatic duct* is usually very slender, and its connexions are inconstant. A common arrangement is as follows:—

As the principal duct enters the head it gives off the *accessory duct*, which runs towards the right through the upper part of the head and opens into the medial side of the duodenum farther forward than the principal duct and about an inch higher. It receives small tributaries from the upper part of the head, but its chief tributary arises in the anterior lobules of the lower part of the head and runs upwards in front of the principal duct (Fig. 173). In certain circumstances the accessory duct may acquire some importance. If the flow of pancreatic juice is obstructed at the termination of the principal duct—for example, by the impaction of a gall-stone in the ampulla of the bile-duct—the accessory duct can enlarge and convey the juice from the principal duct to the duodenum.

The point at which the pancreatic duct joins the bile-duct is variable; and, indeed, the two may open separately into the duodenum.

The accessory duct is even more variable. When well-developed, its opening into the duodenum is on the summit of a little nipple that resembles the duodenal papilla in miniature and may ape that papilla by having a little hood and a little longitudinal fold. But the duct is sometimes so small that its opening is found only with difficulty; and sometimes, failing to reach the duodenum, its right end is a tributary from a lobule. In such a case, the juice from the territory drained by it passes along it from right to left into the principal duct.

The dissectors should now proceed to expose the pancreatic ducts. Though the principal duct in most of its course is nearer the front of the pancreas than the back, the dissectors should expose it from the posterior surface as its terminal part is nearer the back and its entrance into the duodenum is on the postero-medial surface.

Dissection.—Lay the pancreas and duodenum (with the attached spleen) on the table with their posterior surfaces uppermost. Make two parallel cuts into the body of the pancreas near the two borders. Pick away the substance of the pancreas at any point between the cuts till the duct is reached (it will be recognised by its greyish-white colour); trace it first towards the tail and then towards the head, following the tributaries for a short distance into the substance of the gland. When the head is approached, exercise caution; trace it carefully to its termination, and then follow its tributaries from the head. One of the tributaries that join it near the point where it enters the head will turn out to be the *accessory duct*. Trace it to the duodenum; secure its tributaries, and clean the one that ascends to it from the lower part of the head.

Having completed the dissection and examined the ducts, lay aside the pancreas, duodenum and spleen carefully, and proceed to study the *liver*.

Hepar.—The liver is the largest gland in the body and has manifold activities, including, among others, the metabolism of carbohydrates and proteins after their absorption from the intestines, and the more obvious function of secreting the bile, which is discharged into the intestines by the bile-duct and is an important agent in the digestion of fats. Being so active an organ, it is very vascular. Arterial blood is supplied to it by the hepatic artery; and the portal vein brings a flood of blood carrying materials from the intestines.

Relation to Thorax.—As the ribs are important landmarks for the position of the liver, the dissectors should, if the thorax is still intact, identify the ribs again and note the position of the nipples and the xiphi-sternal joint and their relation to the upper surface of the liver, and then ascertain which ribs are superficial to the liver. If the thorax has been opened, pass the hand over the upper surface of each half of the diaphragm and find out how far down the pleura (or lining membrane of the thorax) reaches, and to what extent it overlaps the liver; identify also the remains of the pericardium and ascertain the position occupied by the heart, in order that their relation to the liver may be understood.

When this investigation has been made, remove the right lobe of the liver from the abdomen, and re-attach the left lobe (which has been removed already), in order to examine the surfaces of the liver as a whole; and replace the liver from time to time as its relations are studied.

Dissection.—Pull the liver downwards; divide the *alciform ligament* from before backwards, and then cut through the *upper layer of the coronary ligament* from right to left, taking care, as the left end is approached, not to injure the inferior vena cava, which is immediately behind it. Raise up the liver to expose the vena cava between the duodenum and the liver, and strip the peritoneum off the vena cava. Next, raise the liver still more, and cut through the *lower layer of the coronary ligament.* Then, pull the liver forwards and to the left, and, with the fingers, separate it from the diaphragm till the right border of the vena cava is reached. Now, from below upwards, separate the vena cava from the liver till the entrance of the hepatic veins into the vena cava is reached; divide them carefully; and, cutting or tearing the peritoneum reflected from the caudate lobe to the diaphragm, remove the liver. The inferior vena cava may be so deeply embedded in the back of the liver that it must be divided and removed with the liver.

Characters, Size and Position of Liver.—The liver is reddish-brown in colour; and, as it is almost entirely clothed with peritoneum, the surfaces are smooth and glistening. A little manipulation will prove that it is easily lacerated ; and a "ruptured liver" is a serious condition that may result from an accident during life. Close inspection will show that the torn surface is granular and the unbroken surfaces are mottled. The granular appearance and the mottling are due to multitudes of minute hepatic *lobules* imperfectly separated by the areolar tissue in which the nerves, vessels and biliary ducts lie.

In an adult, the liver is about one-fiftieth of the body-weight and occupies the uppermost part of the abdomen chiefly on the right side ; and a very great part of it is in close relation with the diaphragm and therefore under shelter of the ribs, which give the protection that so vulnerable an organ requires. But at birth, it is relatively much larger, especially the left lobe—about one-twentieth of the body weight and even more —and occupies a very great part of the abdominal cavity. The bulging prominence of an infant's abdomen is partly due to the fact that the pelvis is not roomy enough to hold the viscera that subside into it after the sixth year, but is chiefly due to the large size of the liver.

General Form.—In its natural state, the liver is so soft and pliable that, when it is taken out of the body and laid on a table, it flattens out into an almost jelly-like cake with only upper and lower surfaces. During life its shape and contours therefore alter greatly with the position of the body and the condition of the hollow organs near it. However, when it is hardened *in situ* with the body lying on its back, its contours are fairly constant in different bodies, and in shape it more or less resembles a thick wedge ; and it is convenient to describe it as having the five surfaces presented by that wedge-like form, namely, superior, inferior, anterior, posterior, and a right lateral—the right lateral being the base of the wedge. In well-hardened specimens, these surfaces can usually be distinguished from one another at a glance :— the *base*, markedly convex ; the *anterior* surface, slightly convex ; the *superior* surface, slightly concave in the middle ; the *posterior* surface, markedly concave from side to side near its left end ; and the *inferior* surface, very uneven and sloping. Further, the inferior surface is marked off by a distinct *inferior border*, which runs round it and is sharpest anteriorly, while the other surfaces pass into each other over indistinct, rounded borders.

Before the surfaces are considered further and their relations studied, certain other features must be noted.

Fissures of Liver.—Far back on the inferior surface of the right lobe, near the left lobe, there is a transverse fissure called the **porta hepatis**. It is deep and wide and about two inches long. A portion of the lesser omentum is attached to its lips; and it transmits the terminal branches of the portal vein and of the hepatic artery, the common hepatic duct, the nerves of the liver and most of its lymph-vessels. Besides these, it contains fatty tissue and, occasionally, two or three lymph-glands, which, when enlarged, may obstruct the flow of bile in the hepatic ducts. The common hepatic duct is formed in the right part of the porta by the union of the right and left hepatic ducts. The branches of the hepatic artery enter on the left side of the common duct, and then pass behind the right and left ducts; and the branches of the portal vein are behind the arteries. It will be seen later that the porta is bounded anteriorly by the quadrate lobe, and posteriorly by the caudate lobe and its caudate process.

The **fissure for the ligamentum teres** is a deep, narrow cleft that begins at the left end of the porta and runs forwards and downwards in the inferior surface to a notch on the inferior border. It lodges the ligament that gives it its name; and it is sometimes bridged over by a band of liver substance called a *pons hepatis*.

The **fissure for the ligamentum venosum** is a deep, narrow vertical cleft that cuts into the posterior surface and extends from the upper surface to the left end of the porta. The upper part of the lesser omentum passes into it to be attached to the bottom of it; and its sides are lined with the peritoneum which is continuous with the layers of the omentum at their attachment. The ligamentum venosum runs upwards in the deepest part of it.

The *ligamentum venosum* is the slender, fibro-muscular remnant of a wide channel called the *ductus venosus*. Up to the time of birth the *umbilical vein* brought the pure blood from the placenta to the left branch of the portal vein, and the ductus carried that blood to the inferior vena cava. Soon after birth these vessels shrivel: the umbilical vein becomes the ligamentum teres and the ductus becomes the ligamentum venosum. The ligamentum venosum springs therefore from the left branch of the portal vein; it ascends to the upper end of its fissure and then curves towards the right in a groove that limits the caudate lobe superiorly, and it is fixed to the medial side of the inferior vena cava at the point where the vena cava leaves the liver.

Lobes of Liver.—The liver is partially divided into a large **right lobe** and a small **left lobe** by the fissure for the ligamentum venosum on the posterior surface and the fissure for the ligamentum teres on the inferior surface; the attachment

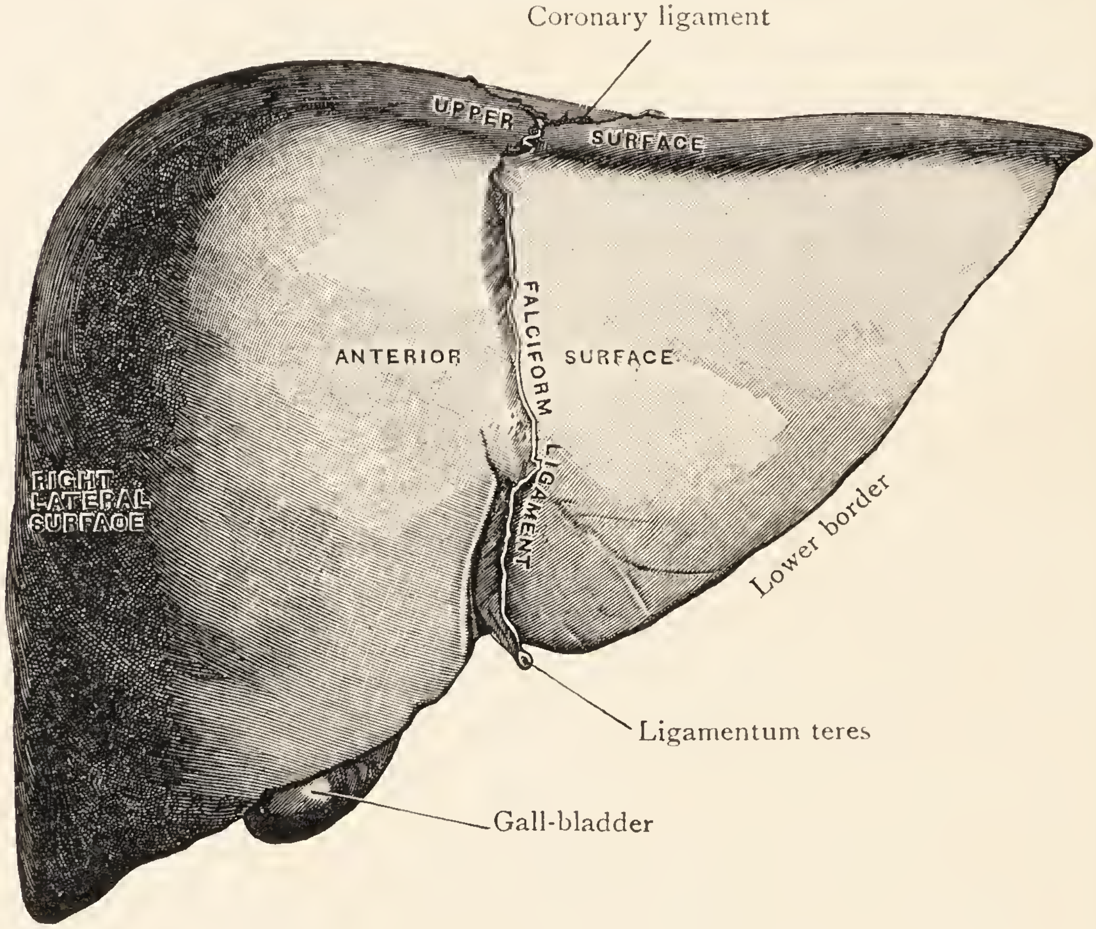

FIG. 175.—Liver from the front.

of the falciform ligament is taken as the boundary between the lobes on the superior and anterior surfaces. Besides these two main lobes there are two circumscribed areas on the medial part of the right lobe which are dignified by the name "lobe":—(1) The *caudate lobe* on the posterior surface, between the inferior vena cava and the fissure for the ligamentum venosum; (2) the *quadrate lobe* on the inferior surface, between the gall-bladder and the fissure for the ligamentum teres.

The students will now pass to the consideration of the surfaces.

Surfaces of Liver and their Relations.—The **base** or **right**

lateral surface is roughly quadrilateral and is convex. It is closely related to the diaphragm opposite the seventh to the eleventh ribs (in the mid-axillary line) and to the transversus abdominis for half an inch below the rib-margin. The pleura and lung are important relations, though separated by the diaphragm; in the mid-axillary line, the pleura overlaps the liver down to the level of the tenth rib, and the lung down to the eighth.

The **anterior surface** is triangular and slightly convex. A

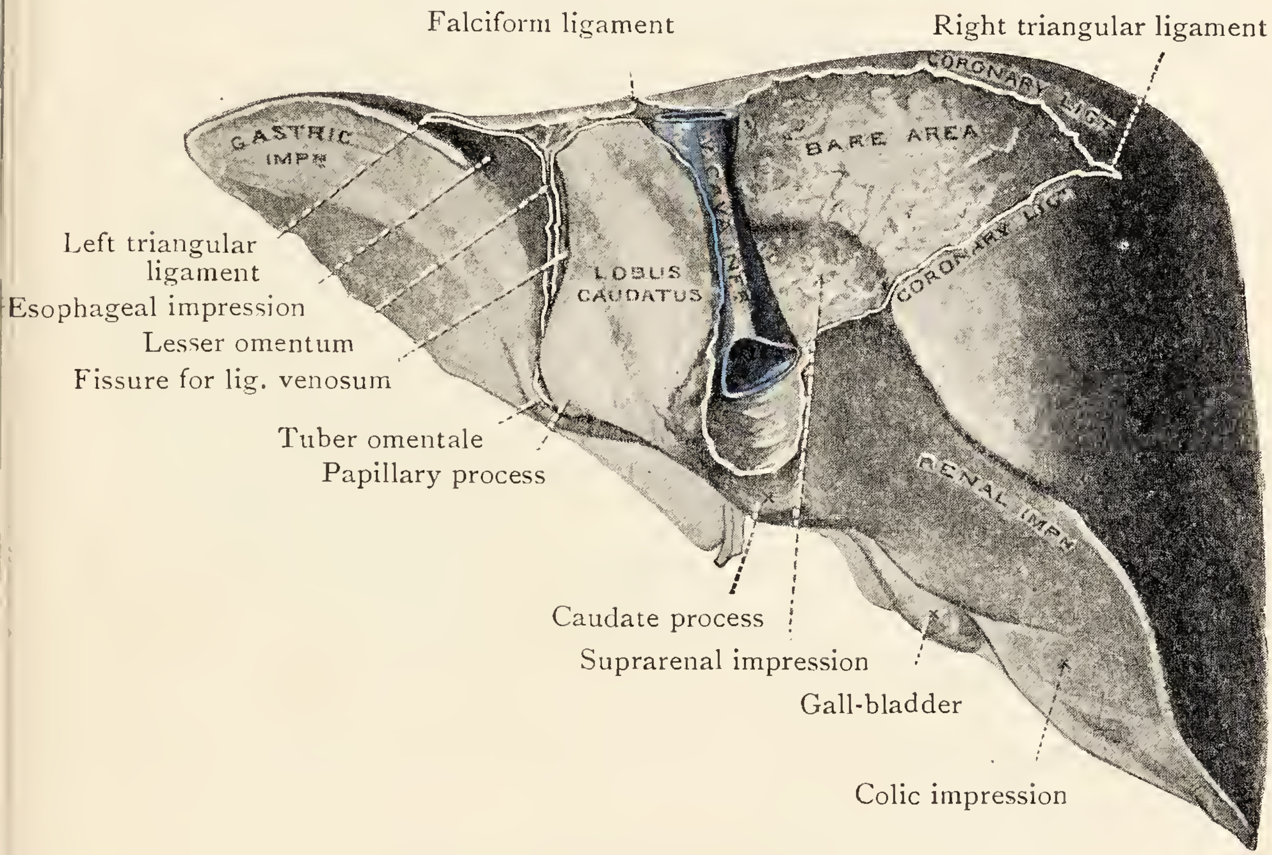

FIG. 176.—Liver from behind.

large part of it is related, in the middle, to the anterior abdominal wall (including the xiphoid process) between the right and left costal margins (Fig. 120), but the portion belonging to the left lobe is partly separated from the wall by the falciform ligament. The small part to the left of this Λ-shaped portion and the large part to the right are related to the diaphragm, which separates them from the pleuræ, lungs and ribs. Replace the liver and note the extent to which the pleuræ and lungs are in relation to it. The pleura reaches down to the level of a curved line drawn from the xiphi-sternal joint towards the tenth rib in the mid-axillary line, and the lung to a line drawn from the joint towards the eighth rib (Fig. 11, p. 24).

The **superior surface** is oblong and is closely related to the diaphragm, which separates it from the pericardium and heart in the middle and from the pleura and lung on each side. To fit the diaphragm, the middle part (below the heart) is slightly concave; and, in the median plane, it is in line with the xiphi-sternal joint. On the right, it rises into a convexity that reaches almost to the level of the right nipple. On the left, there is a less-marked convexity, and the surface ends at a thin edge that separates it from the inferior surface; this edge is opposite the fifth rib in a line dropped from the left nipple.

The **posterior surface** is roughly triangular in outline and is markedly concave from side to side, because it is moulded on the pronounced median bulge of the uppermost part of the posterior wall of the abdomen. Identify the *fissure for the ligamentum venosum* again. Note that the part of this surface that belongs to the left lobe is narrow, but that it widens near the fissure and is marked there by a shallow *œsophageal impression* for the abdominal part of the œsophagus and the anterior lip of the œsophageal opening of the diaphragm. The part that belongs to the right lobe is very large, for the surface widens abruptly immediately to the right of the fissure for the ligamentum venosum and widens further as it is traced towards the right. Four parts are to be specially noted:—the caudate lobe; the inferior vena cava or the groove in which it lay; the " bare area "; and a depression made by the right suprarenal gland.

The *caudate lobe* is the oblong, circumscribed area in the deepest part of the concavity. It is mostly to the right of the median plane and is related to the diaphragm above the aortic opening. It is separated from the diaphragm by a recess of the lesser sac of peritoneum; and the diaphragm separates it from the *thoracic* aorta opposite the last two thoracic vertebræ. It is bounded on the right by the groove for the inferior vena cava, on the left by the fissure for the ligamentum venosum, and superiorly by the groove for the ligamentum venosum and the left hepatic vein as they arch across to join the inferior vena cava. Inferiorly, it has a free end, which forms part of the posterior lip of the porta hepatis and juts down behind the lesser omentum. From the right side of its lower end a ridge of liver-substance passes laterally between the vena cava and the portal vein. This " tail " is called the *caudate process* and gives the name to the lobe; it forms the rest of the posterior lip of the porta and connects the caudate lobe with the rest of the right lobe. The cœliac artery (behind the posterior wall of the lesser sac) sometimes notches a hardened specimen, and the portion to the left of the notch is called the *papillary process.*

The *groove for the inferior vena cava* is a wide, deep, vertical groove immediately to the right of the caudate lobe,

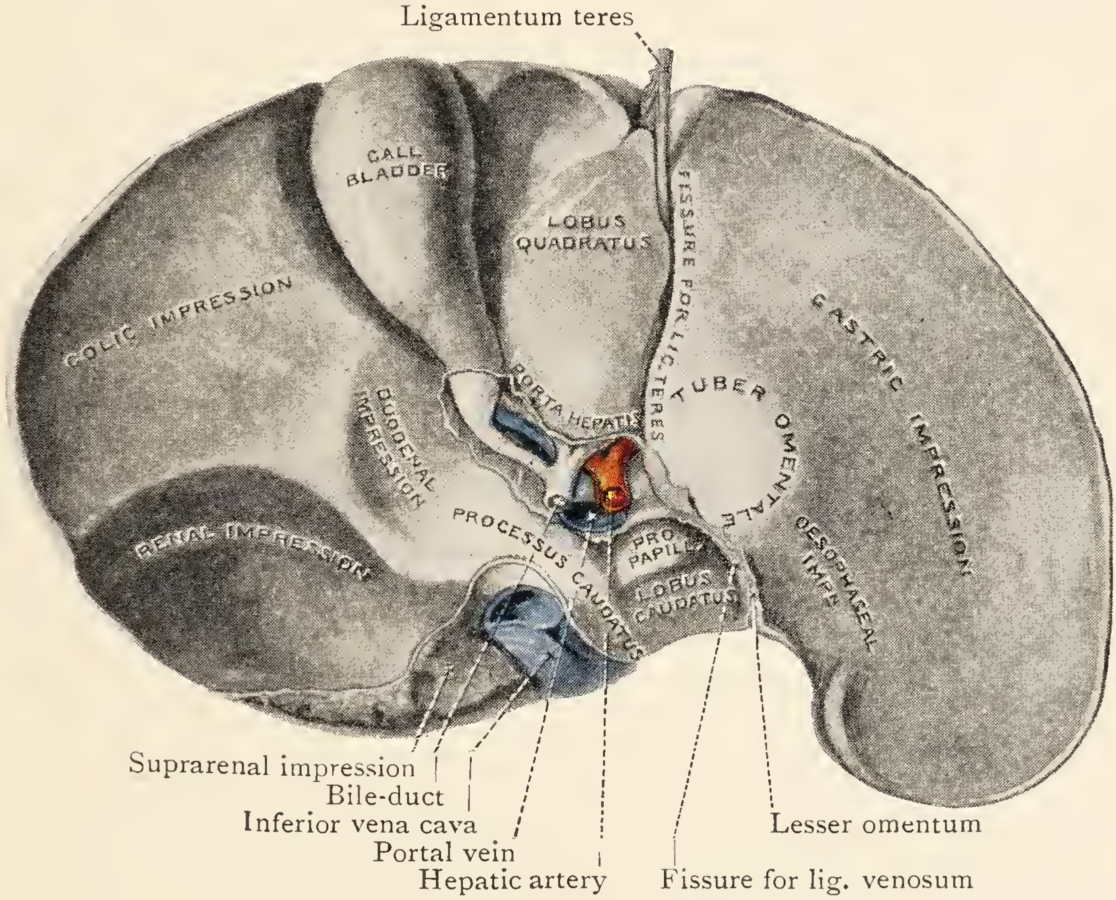

FIG. 177.—Liver from below and behind.

which usually overlaps the vena cava behind and may, in part, bridge over the groove, forming another *pons hepatis.* At the upper part of the groove, the ends of the two main hepatic veins will be seen; and the ends of smaller hepatic veins will be seen lower down.

The rest of the posterior surface is wide and convex, and related to the diaphragm. A great part of it, immediately adjoining the vena cava, is called the "bare area" because it is devoid of peritoneum. The layers of the coronary ligament are reflected on to the diaphragm from the upper and lower margins of the bare area, which is in direct contact with the diaphragm and is connected with it by areolar tissue through which lymph-vessels and small veins pass.

The *suprarenal impression* is a very shallow depression in the lower part of the bare area close to the vena cava ; this is only the upper part of the suprarenal impression ; the lower part is on the inferior surface.

The **inferior surface** is oblong and very uneven. It is so oblique that it looks backwards and to the left as much as downwards ; and, as all parts of it are in relation to viscera, a more appropriate name is the **visceral surface**.

The portion that belongs to the left lobe is related to the stomach and the lesser omentum. In a hardened liver, the *gastric impression* is a wide, shallow concave area to the left and in front. The omental part is a bulging prominence to the right and behind, and is called the *tuber omentale*.

The most striking feature on the right lobe is the gall-bladder, lying in a shallow, pear-shaped *fossa* that extends from the right end of the porta to a wide, shallow notch on the inferior margin of the liver.

The four-sided area between the gall-bladder and the fissure for the ligamentum teres is the *quadrate lobe*, which extends from the porta to the inferior margin. It is in relation with the lesser omentum near the porta, with the transverse colon near the inferior margin, and with the pylorus and beginning of the duodenum between those two.

The remainder of the right lobe is in relation :—(1) with the end of the first part of the duodenum, at the neck of the gall-bladder ; (2) with the beginning of the second part, lateral to the posterior part of the gall-bladder ; (3) with the right flexure of the colon, lateral to the anterior part ; (4) with the upper part of the right kidney, behind and above the flexure and the duodenum ; and (5) with the lower part of the right suprarenal gland, medial to the kidney. These structures leave shallow impressions of varying width in a hardened specimen, the renal impression being the widest and best marked.

Peritoneal Connexions of Liver.—The liver is completely clothed with peritoneum, except in three situations, viz., the bare area, the groove for the inferior vena cava and the fossa for the gall-bladder. Along certain lines the peritoneum is reflected from it to form folds which connect it with the anterior abdominal wall, with the diaphragm, and with the stomach and duodenum. These folds are the falciform ligament, the coronary ligament, the right and left triangular ligaments, and the lesser omentum—and they have been described already. Although these folds are reflected from different parts, the lines of reflexion run into one another, forming one continuous, intricate line which can be traced in Figs. 175-177.

Vessels and Nerves of Liver.—The liver is a very vascular organ, for not only does the **hepatic artery** bring arterial blood for the sustenance of the liver but the **portal vein** also brings a great quantity of blood that contains materials upon which the liver exerts its special actions. The blood is drained away by the **hepatic veins,** which open into the inferior vena cava as it lies in the groove on the back of the liver. Some of these veins are small and open into the vena cava at inconstant points ; but the chief veins are a *right* and a *left hepatic vein* from the right and left lobes, and they enter the vena cava immediately before it leaves the liver. The right vein is very wide, and joins the vena cava as soon as it emerges from the liver. The left vein—much narrower—emerges from the left lobe at the upper end of the fissure for the ligamentum venosum, and crosses the upper end of the caudate lobe to reach the vena cava.

The **nerves** are sympathetic fibres from the cœliac plexus and filaments which come from the vagi through the gastric nerves.

The **lymph-vessels** follow two main routes. Some emerge through the porta and end in hepatic lymph-glands in the porta and in the lesser omentum. Others emerge through the back of the liver ; some of these end in glands near the upper border of the pancreas, and some pierce the diaphragm and end in glands of the thorax.

The dissectors will now examine the gall-bladder. When they study its relations they must bring the liver and the duodenum (with the pancreas and spleen) back to the abdomen, and fit them into position again.

Vesica Fellea.—The **gall-bladder** is the reservoir in which the bile, after its exit from the liver, is stored and is concentrated by the absorption of some of its liquid contents.

Taking advantage of this concentration, radiologists are able to show the position of the gall-bladder in the living body, because a certain opaque dye, when administered by mouth or by injection, is excreted by the liver and passes into the gall-bladder, where it is concentrated with the bile (Figs. 170, 171).

Size and Position.—The gall-bladder is a small, piriform sac that can hold from one to two fluid ounces. It lies in a shallow fossa on the visceral surface of the liver, and is held in position partly by areolar tissue and by small veins that pass from it into the liver but chiefly by the hepatic peritoneum which passes across its lower surface from one margin of the fossa to the other. It is oblique in position, its long axis being directed backwards and upwards and slightly medially from the lower edge of the liver to the right end of the porta hepatis.

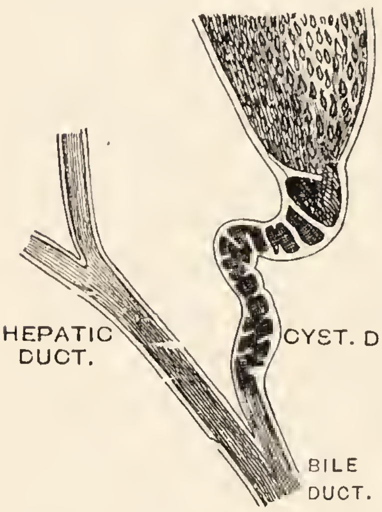

FIG. 178.—Diagram of Cystic and Hepatic Ducts. (From Gegenbaur, modified)

Parts and Relations.—It has a body, a fundus and a neck. The *fundus* is the anterior or lower end of the sac and is the wide end. Usually, it protrudes beyond the edge of the liver and is clothed therefore on all sides with peritoneum. It is in relation posteriorly with the transverse colon, and anteriorly with the anterior abdominal wall at a varying point, but very frequently opposite the upper end of the right linea semilunaris immediately below the ninth costal cartilage. The main part or *body* is clothed below and at the sides with peritoneum. Its superior or anterior surface is in direct contact with the liver; its inferior or posterior surface is related to the transverse colon and to the second part of the duodenum above the colon. The *neck* is the narrow end of the sac and is continuous with the cystic duct. The neck is closely applied to the liver near the right end of the porta and is in relation inferiorly with the end of the first part of the duodenum (Figs. 169, 177).

Vessels and Nerves.—The gall-bladder is supplied by the cystic artery and vein. Its nerves accompany the artery; they include sympathetic fibres from the cœliac plexus and fibres from the right vagus and phrenic. The lymph-vessels pass to lymph-glands that lie alongside the cystic duct and in the porta hepatis.

Cystic Duct.—The duct of the gall-bladder is a narrow tube, an inch or more in length. It enters the lesser omentum at the right end of the porta, makes an S-shaped bend, encounters the common hepatic duct, and runs downwards with it for a short distance before joining it to form the bile-duct.

Remove the liver (and the other organs) from the abdomen again, and examine the arrangement of the vessels and ducts in the porta hepatis. Do not be surprised if the arrangement differs from that described, for variations are very common.

> ***Dissection.***—**Remove all the fat and areolar tissue from the porta, and trace the vessels and ducts until they sink into the liver-substance.**

Structures in Porta Hepatis.—The arrangement of the ducts and vessels commonly described is as follows :—

The **portal vein,** the **hepatic artery** and the **bile-duct** lie in the free margin of the lesser omentum below the right or lateral part of the porta hepatis—the artery medial to the duct, and both of them in front of the vein. Immediately below the porta the artery and vein divide into right and left branches which enter the right part of the porta ; and the **common hepatic duct,** after issuing from that part of the porta, joins the **cystic duct** to form the bile-duct. At the lips of the porta, the **fibrous capsule** that encloses the liver is reflected inwards to line the walls of the porta and to enclose the fatty areolar tissue that surrounds the vessels and the ducts.

The *right branch of the portal vein* receives the *cystic vein* and then sinks into the right lobe. The *left branch* is narrower and longer ; it runs medially along the bottom of the porta, giving branches to the caudate and quadrate lobes, and at the left end of the porta it sinks into the left lobe; immediately before it disappears it gives attachment to the ligamentum teres and ligamentum venosum.

The *branches of the hepatic artery* are in front of the veins; they are correspondingly dissimilar in width and length, and accompany the veins into the lobes.

The *left hepatic duct* issues from the left lobe at the point where the vessels enter, and runs to the right (receiving tributaries of the caudate and quadrate lobes) to join the *right duct* near its point of emergence from the right lobe. These ducts are in front of the vessels, and the *common hepatic duct*, formed by their union, escapes from the porta in front of the right branch of the hepatic artery.

Variations.—These are of some importance to the surgeon.

The right and left hepatic ducts may extend out of the porta, and may even fail to unite till they join the cystic duct; occasionally, there is an additional duct from the right lobe. The bile-duct may be shortened by an unusual descent of the cystic duct and common hepatic duct into the lesser omentum ; on the other hand, the bile-duct may be formed between the lips of the porta. The gall-bladder may receive some small ducts directly from the substance of the liver ; occasionally, it is partially embedded in the liver, or, contrariwise, it may be attached to the liver by a short fold of peritoneum.

The right branch of the hepatic artery may cross in front of the common duct instead of behind it ; and the cystic artery may arise from the hepatic trunk and cross the bile-duct. The hepatic artery may arise directly from the aorta or from the superior mesenteric, and it may be replaced or supplemented by a branch from the aorta that enters the back of the liver. The left branch may be replaced wholly or in part by an artery that arises from the left gastric in the lesser omentum.

The dissectors should now endeavour to make out some of the grosser features of the structure of the liver.

> ***Dissection.***—**Trace a branch of the portal vein for some distance into the substance of the liver, together with the artery and the duct, and note that where the branches of the vein divide the branches of the artery and duct do so also. Turn to the back of the liver, and trace a hepatic vein into its substance. Then, cut a thin slice off the left lobe near the porta, and examine the surface with a pocket-lens.**

Structure of Liver.—The liver is enclosed in a very thin fibrous capsule, which is slightly thicker where the peritoneum is absent. The deep surface of the capsule is connected with the areolar tissue between the lobules, but it is easily stripped off with the peritoneal coat, for, in the human liver, the interlobular areolar tissue is reduced to a minimum. At the lips of the porta, the capsule passes into it to line its walls.

As the portal vein and the artery and duct pierce the capsule of the liver at the bottom of the porta they drag in with them a distinct fibrous sheath which closely envelops them and divides to ensheath their branches. In a favourable specimen, the pocket-lens will show :—(1) Here and there, a group of vessels enclosed in a fibrous ring ; these are a small artery, a larger duct, and a still larger vein—a branch of the portal vein—usually collapsed. (2) Here and there, an unaccompanied vessel, widely open, with very thin walls, and with so little areolar tissue around it that it seems to be in direct contact with the liver-substance ; these are the tributaries of a hepatic vein.

The smallest branches of the *portal vein* form networks between the lobules and end in capillary-like channels, called *sinusoids*, inside the lobules. The branches of the *hepatic artery* supply the ducts and the fibrous sheath, and also end in the sinusoids. Within each lobule there is a *central vein* which collects the blood from the sinusoids. The central veins emerge from the lobules and unite to form *interlobular veins*, which unite to form the tributaries of the *hepatic veins*.

The bile is drained from the lobules by *bile-ductules*; they unite to form *interlobular ducts*, which unite to form the right and left *hepatic ducts*.

Complete the study of the biliary arrangements by examining the structure of the gall-bladder and the ducts.

> ***Dissection.***—**Make an incision through the lower wall of the gall-bladder from the fundus to the neck ; extend the cut along the cystic duct into the upper part of the bile-duct ; open them and sponge them out.**

Structure of Gall-Bladder and Ducts.—The walls of the gall-bladder and the ducts are constructed of a coat of non-striped muscle mixed with fibrous tissue, a thin submucous coat, and a mucous coat (stained green with bile). The gall-bladder has also a partial serous coat of peritoneum.

The mucous coat of the gall-bladder is raised into a large number of small ridges joined together in a way that gives it the appearance of a honey-comb—seen better when examined with a pocket-lens. At the neck, a prominent ridge appears which runs spirally along the cystic duct, but is interrupted at intervals. It probably controls the flow of bile from the gall-bladder; and it is called the *spiral valve*.

Relations between Thoracic and Abdominal Organs. —If the thorax has been opened, put the liver back into the abdomen, and review the relations of the thoracic organs that

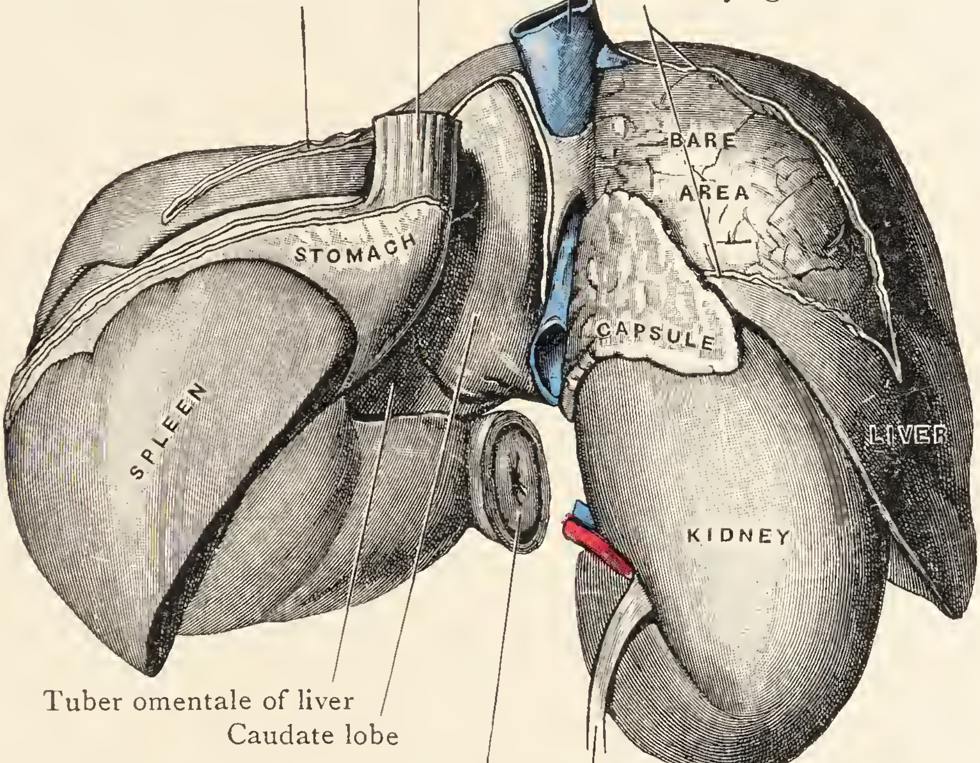

FIG. 179.—Liver, Right Kidney, Spleen and Stomach, as seen from behind. Drawing made from a model prepared by the reconstruction method.

lie on the diaphragm to the chief abdominal organs that are in contact with it below (Figs. 179, 192).

The right vault of the diaphragm is occupied by the right lobe of the liver and the right kidney, the left vault by the left lobe, the stomach, the spleen and the left kidney. The right lobe of the liver is to a large extent in relation with the right pleura, to a lesser extent with the base of the right lung, and to a slight extent, near the median plane, with the pericardium and heart. The left lobe of the liver is in relation with the rest of the lower surface of the pericardium and heart, and separates their left part from the stomach. Both the left lobe and the stomach are related to the left pleura and to a less extent to the left lung. Nearly the whole of the diaphragmatic surface of the spleen is in relation with the left pleura, and its upper third with the left lung also. Each kidney and suprarenal gland are separated by the diaphragm from the lowest part of the pleura—which is a very important posterior relation of the kidney—but the lung does not reach down to their level. The relation to the pleura is very intimate when there is a deficiency in the posterior part of the diaphragm (p. 376).

Place the liver beside the duodenum, pancreas and spleen, and retain them for occasional replacement when the relations of the kidneys are studied. Return to the abdomen to study the structures on its posterior wall, beginning with the cœliac plexus, most of which has been cleaned already.

Dissection.—Find the *left cœliac ganglion* behind the part of the splenic artery that was retained. Trace its branches into the suprarenal gland. Separate the lobules of the ganglion carefully, and look for a small artery—the *middle suprarenal*—which runs from the aorta to the gland. Find the *right cœliac ganglion*, and deal in like manner with it, pushing the inferior vena cava (if it was not removed with the liver) first to one side and then to the other. Trace an offshoot of the cœliac plexus on to the stump of the superior mesenteric artery; and then follow the continuation of the plexus down over the aorta to the inferior mesenteric artery—below which point the aortic plexus has been dissected already.

Sympathetic Nervous System.—Before the dissectors begin the study of the sympathetic plexuses, they require to have a general idea of the system to which the plexuses belong.

The sympathetic nervous system, as a whole, consists of:—(1) the sympathetic trunks, with their ganglia and branches; and (2) numerous plexuses of fine nerves which are associated with viscera and with the arteries that supply them, and in which there are scattered ganglia.

Sympathetic Trunks.—These trunks are a pair of slender cords that lie in close relation with the front of the backbone from the upper cervical vertebræ to the coccyx. Small ganglia are placed on them at intervals and give them a knotted appearance. They are connected with the anterior primary rami of all the spinal nerves by slender branches called rami communicantes; and they send branches into the sympathetic plexuses.

Sympathetic Plexuses.—The chief plexuses are :—(1) the cardiac, on the bifurcation of the trachea ; (2) the cœliac, around the cœliac artery and continued into the superior mesenteric and aortic plexuses ; and (3) the hypogastric, which lies between the two common iliac arteries and bifurcates into the right and left pelvic plexuses. Offshoots of these plexuses can be traced along various arteries and their branches, and end ultimately in delicate plexuses in the walls of viscera. The ganglia found in them and on the sympathetic trunks are cell-stations where the efferent sympathetic fibres are relayed. Those in the walls of viscera are microscopic ; the others vary from pin-head size upwards ; the cœliac ganglia are the largest, and are like large lymph-glands.

Autonomic Nervous System.—The sympathetic system is the most obvious part of a subdivision of the nervous system called the autonomic nervous system, whose fibres supply the non-striped muscle and the glandular epithelium throughout the whole body, including all blood-vessels and the hair-muscles and glands of the skin. Autonomic nerve-fibres are contained therefore in the cranial and spinal nerves as well as in sympathetic nerves. Certain of these fibres have been grouped under the distinctive name of **parasympathetic system.** These " parasympathetic " fibres are :—(1) Fibres of the third cranial nerve that are relayed in a ganglion for two muscular structures inside the eyeball ; (2) secretory fibres of the seventh and ninth cranial nerves that are relayed in ganglia for the lacrimal and salivary glands ; (3) fibres of the tenth nerve (*i.e.* the vagus) that supply viscera ; (4) branches of the second and third, or third and fourth, sacral nerves which join the pelvic sympathetic plexuses and are distributed through them to the pelvic organs and the lower part of the colon.

Many of the visceral branches of the vagus and all the parasympathetic fibres of the sacral nerves are distributed in the abdomen, and are therefore of special interest to the dissectors of the Abdomen.

The aortic and hypogastric plexuses are described on p. 310.

Cœliac Plexus.—The cœliac plexus is a thick meshwork of small nerves that lies on the aorta around the cœliac artery, and on the crura of the diaphragm ; it is therefore behind the lesser sac of peritoneum, opposite the lower part of the lesser omentum ; it is overlapped on the right by the inferior vena cava, and inferiorly by the pancreas. It is the largest of the sympathetic plexuses in the abdomen proper, and is notable also for the fact that it contains the largest pair of ganglia in the body—the cœliac ganglia.

Cœliac Ganglia.—Each cœliac ganglion is about an inch in diameter, and consists of several nodular masses closely bound together by nerve-fibres. The greater splanchnic nerve enters its upper part, and the lesser splanchnic its lower part. (These nerves arise from the sympathetic trunk in the thorax, pierce the crus of the diaphragm, and enter the ganglion at once.) It lies on the crus of the diaphragm, embedded in the plexus, between the cœliac artery and the suprarenal gland. The middle suprarenal artery passes behind it or threads its way through it ; the phrenic artery passes close by its upper border ; the right ganglion is largely or wholly hidden behind the inferior vena cava ; and the lower part of the left ganglion is crossed by the splenic artery.

A large number of nerves arise from different parts of the ganglion and interlace to form the greater part of the plexus ; the nerves that stream from its lateral border are joined by a few filaments of the greater splanchnic, and pass directly into the suprarenal gland, providing it with a richer nerve-supply than any other organ in the body.

The cœliac plexus is formed therefore by branches of the cœliac ganglia—supplemented by the branches of the vagi brought to it by the posterior gastric nerve. On each side, its ganglion sends branches into the suprarenal gland. Inferiorly, it sends off a large plexus around the superior mesenteric artery, and it is continued downwards, beyond that, as the aortic plexus. Secondary plexuses are sent off from the cœliac and aortic plexuses to accompany all the arteries that arise from the aorta. These plexuses, as they follow the arteries, branch and re-branch like them, and receive the names of the vessels which they accompany.

Certain points are to be noted in connexion with some of these plexuses.

1. Filaments of the phrenic nerve join the *phrenic plexus* on the phrenic artery and reach the suprarenal gland through its suprarenal branches; on the right side, there is a minute ganglion at the point where the phrenic filaments join the plexus. Further, some of these filaments run down to the hepatic artery and are carried by the *hepatic plexus* to the liver and gall-bladder. That may account for the fact that pain in the right shoulder is sometimes a symptom of gall-stones, for the phrenic nerve and the nerves that supply the skin over the shoulder both derive fibres from the same spinal nerve—the fourth cervical.

2. The *renal plexus* surrounds the renal artery ; it is joined by the lowest splanchnic nerve (when it is present), and it contains a few minute ganglia.

3. The *testicular* or *ovarian plexus* is derived from the renal as well as from the aortic plexus.

4. The *mesenteric plexuses* contain ganglia near their origins.

Dissection.—Remove the fat and the fascia from the margins and anterior surface of the *left kidney* and *suprarenal gland*, avoiding injury to the suprarenal vessels and nerves. Find the *left suprarenal vein* ; note whether or not it receives a phrenic vein ; and then trace it into the left renal vein. Find also the *left testicular* (or *ovarian*) vein and trace it to the left renal. Clean the *left renal vein* from the vena cava to the kidney, and follow its tributaries for a little distance through the fat in the kidney. Push the vein first upwards and then downwards to expose and clean the *left renal artery* between its origin and the kidney, and trace branches from it to the suprarenal gland and the ureter. Clean the *left ureter* down to the point where it was cleaned in the dissection of the lower part of the posterior wall of the abdomen.

Next, pass the fingers behind the lateral border of the kidney, turn it medially, clean its posterior surface, and remove the remains of the fat from the ureter and the vessels. Then, clean the muscles, vessels and nerves that lie behind the kidney.

Now, turn to the *right kidney* and *suprarenal gland*. Clean their margins and surfaces ; trace and clean their *vessels* and the upper part of the *right ureter*. Pull forward the kidney, and clean the structures behind it.

Suprarenal Glands.—The suprarenal glands are a pair of important ductless glands. Each of them is a small, soft, yellowish flattened body situated in close relation to the upper part of the kidney.

At birth, the suprarenal glands are almost as large as they are in the adult, and, relative to their adult size, are therefore the largest organs in the body (Fig. 135).

Position and Relations.—**Each suprarenal gland** lies high up on the posterior wall of the abdomen and surmounts the kidney after the fashion of a helmet : it is placed on the summit of the kidney and also along the medial border—the left gland reaching almost to the hilum. But it merely overlaps the kidney and is partly separated from it by fat :

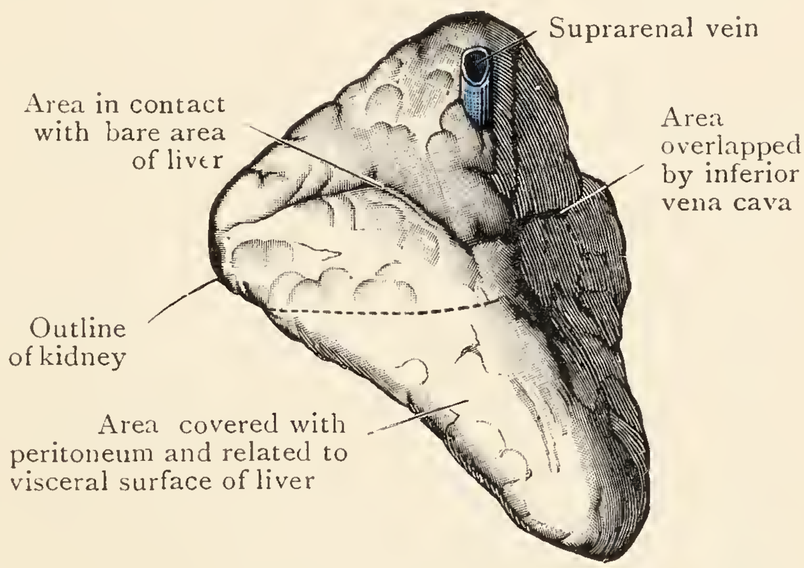

Fig. 180.—Anterior Surface of Right Suprarenal Gland. The dotted line indicates the line of reflexion of the lower layer of the coronary ligament of the liver.

the greater part of the gland lies on the diaphragm above and medial to the kidney. The right and left glands are connected together by the cœliac plexus and ganglia, which send a very large number of nerves into them.

The **right gland** is more or less triangular in outline. It is behind the liver, and is partly separated from the liver by the inferior vena cava, which overlaps its medial part. Its *vein* issues through a slit or *hilum* near its upper end, and enters the vena cava at once. The portion below the level of the bare area of the liver is covered with peritoneum, except occasionally at the lower end, where it may be overlapped by the duodenum.

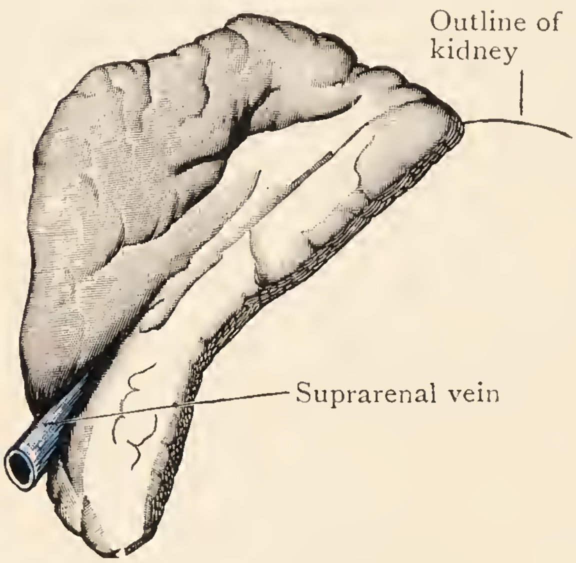

FIG. 181.—Anterior Surface of Left Suprarenal Gland.

The **left gland** is semilunar in outline. It is behind the stomach, forming part of the stomach bed. It is covered therefore with the peritoneum of the lesser sac, except at its lower part, where it is crossed by the splenic artery and overlapped by the pancreas. The medial end of the spleen may reach its upper part, and always does so in the infant. The *vein* issues through a *hilum* near its lower end, and descends to the left renal vein.

Vessels and Nerves.—Though each suprarenal gland has but *one vein*, it has at least *three arteries* whose branches enter it at different points—one ascends from the renal, one (very small) from the aorta, and one or more pass into it from the phrenic. It has been noted already that a *large number of sympathetic nerves* enter it.

Functions.—The propinquity of the suprarenal gland to the kidney is merely an accident of development, and has no functional significance. The external part or cortex of the gland prepares an internal secretion which passes into the blood and exercises a controlling influence on the development and growth of the reproductive organs. The internal part or medulla prepares an internal secretion whose influence is exerted on nearly all tissues supplied by sympathetic nerves—its most manifest effect being constriction of blood-vessels. This is the chief effect of the therapeutic agent called *adrenalin*, which is extracted from the medulla of this organ and is so named because in lower animals the gland, not being above the kidney, is called the *adrenal*.

Dissection.—Make a series of cross-sections through the *right* suprarenal gland. Slit up the hilum of the *left* gland, and trace its vein into the medulla ; then, leaving the vein *in situ*, slice away the anterior part of the gland to display the extent of the medulla. Study the relation of the cortex to the medulla in both, and, with the aid of a pocket-lens, note their more obvious characters.

Structure of Suprarenal Gland.—The whole organ is enclosed in a fibrous capsule. The *cortex* is yellowish in colour, and is streaked at right angles to the surface. This effect is produced by septa of areolar tissue that pass from the capsule into the cortex and divide it into columns of cells. If the specimen is in good condition, even so low a magnifier as a pocket-lens may show that different arrangement of the cells gives rise to three strata or *zones* distinguishable by slight differences in texture.

The *medulla* is much smaller than the cortex, and in sections it appears as a reddish-brown, soft layer sandwiched between two layers of cortex, with offshoots that follow the contours of the gland. It consists of cells arranged in an irregular network with wide meshes filled with blood. Owing to the abundance of blood, the medulla is so diffluent in an unembalmed specimen that there may appear to be a cavity in the gland—whence the old name *suprarenal capsule*.

It is important to note that though the vein issues through the hilum, the branches of the arteries do not enter through the hilum ; they penetrate the surface, and the arterial blood must therefore traverse the cortex before it reaches the medulla.

The large size of the suprarenal gland at birth is due to the thickness of the inner part of the cortex. This special "fœtal cortex," whose function is unknown, is temporary, and disappears during the first year. The growth of the permanent cortex and the enlargement of the medulla do little more than maintain the size of the organ.

Renes.—The **kidneys** are a pair of organs whose function is to remove water, salts and waste-products from the blood ; and the renal vessels are therefore very wide in comparison with the size of the kidneys. The urine, which the kidneys thus excrete, passes into ducts called the ureters, and they convey it to the urinary bladder.

Characters, Size and Parts.—The kidney is reddish-brown in colour, and soft and pliable in consistence ; it is about four or five inches in length, two inches and a half in width and an inch in thickness at its middle ; and it is ovoid in outline —with one border concave, giving it a shape so characteristic and so well-known that "reniform" and "kidney-shaped" are common descriptive terms. The *ends* are upper and lower ; the *surfaces* are anterior and posterior ; the *borders* are lateral and medial. The medial border is the concave border ; in its middle part there is a wide, vertical cleft called the *hilum*, which transmits the ureter and the vessels

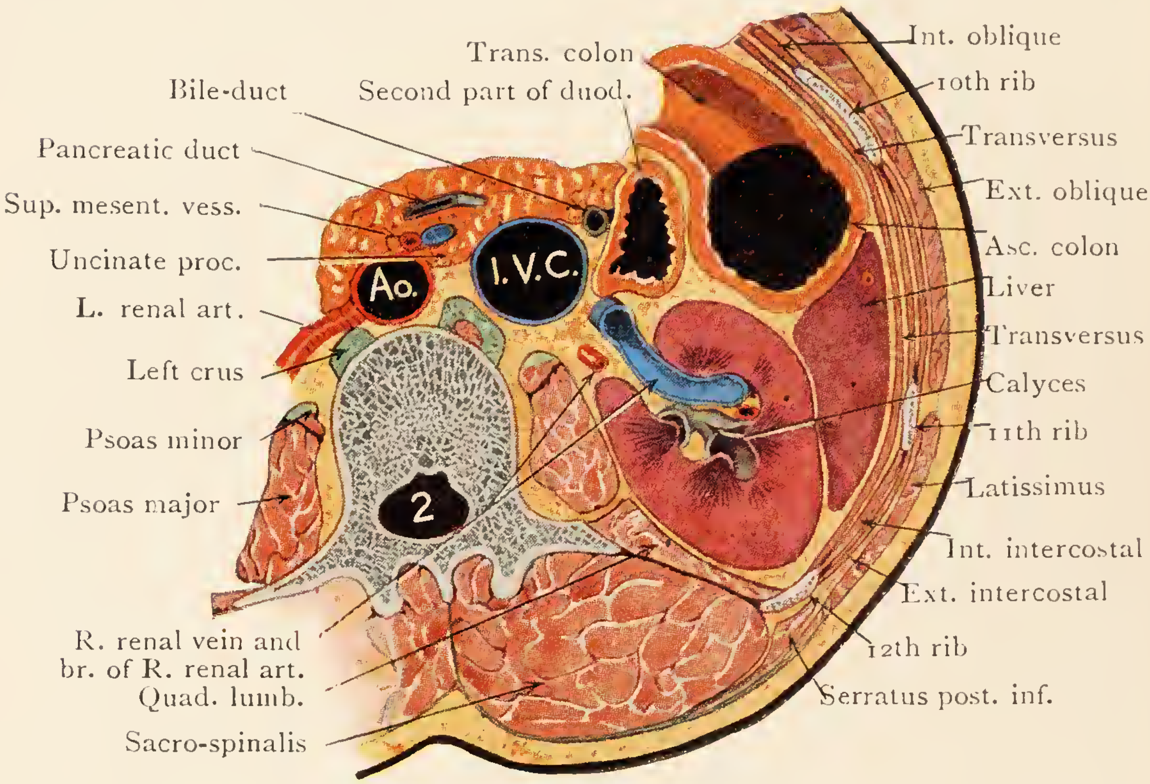

FIG. 182.—Section through Abdomen at the level of the second lumbar vertebra.

and nerves of the kidney. The hilum leads into a space inside the kidney called the *sinus of the kidney*.

A number of structures lie in the sinus and fill it completely :—(1) the short funnel-like tubes called calyces that unite to form the ureter ; (2) the upper part of the pelvis of the ureter, which is its dilated proximal end ; (3) the branches of the renal artery before their entrance into the actual substance of the kidney and the tributaries of the vein after their exit ; (4) the lymph-vessels and nerves of the kidney ; and (5) a quantity of fat around and among the other structures.

At the hilum, the pelvis of the ureter is usually behind the vessels, and the vein is in front of the artery ; some rearrangement takes place in the sinus.

Position and Connexions.—Each kidney lies behind the parietal peritoneum on the upper part of the posterior wall of the abdomen, alongside the last thoracic vertebra and the upper three lumbar vertebræ.

The left is the higher ; it usually reaches the level of the lower border of the eleventh rib. The right, being unable

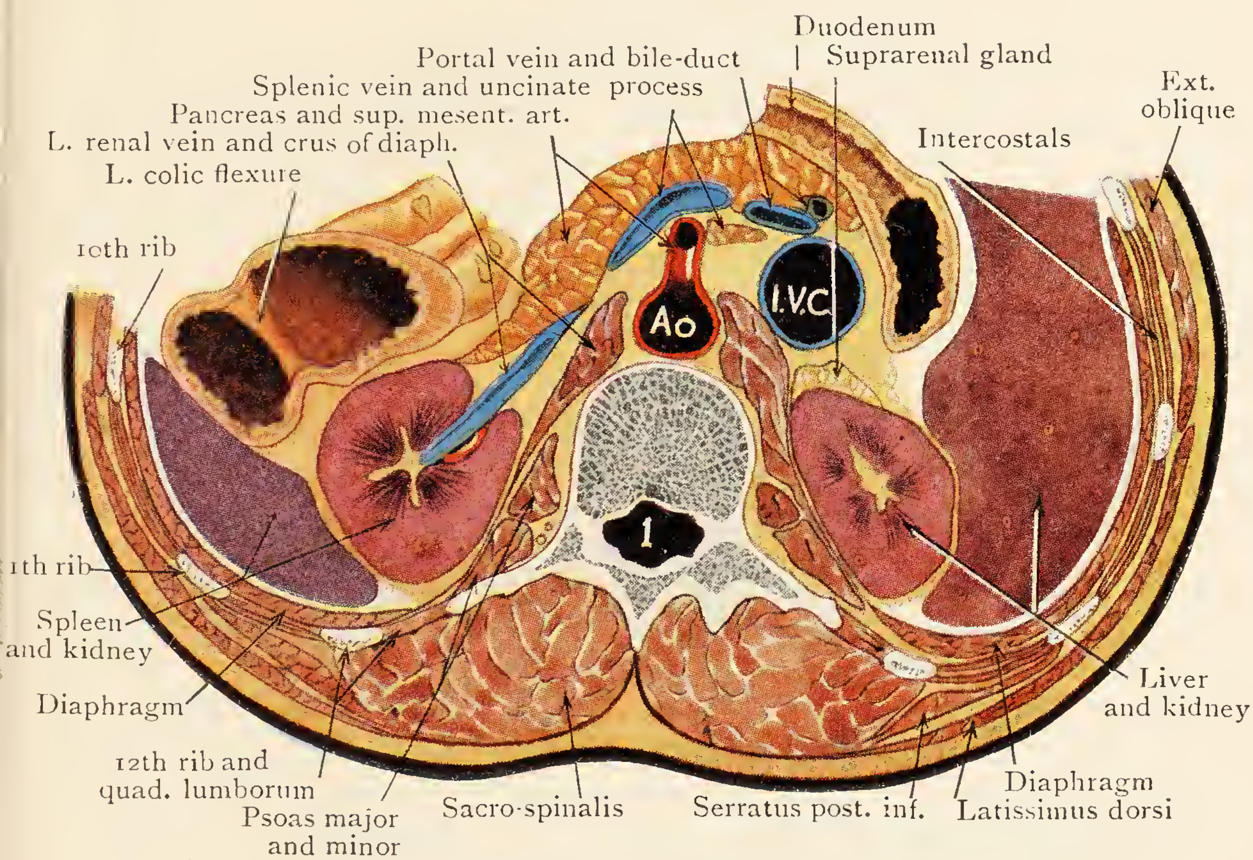

FIG. 183.—Transverse Section through Abdomen at the level of the first lumbar vertebra.

to attain to so high a level owing to the liver, does not reach beyond the middle of the eleventh space (Figs. 170, 184, 193). Their lower ends are separated from the iliac crests by a short but variable interval. The middle of the hilum is two inches (or less) from the median plane ; but the kidney is oblique so that its upper part is nearer the median plane and the lower part is farther away. The kidney slopes in the transverse plane also, for it is moulded on to the side of the median elevation made by the vertebral bodies and the psoas muscles ; its anterior surface looks therefore sidewards as well as forwards ; and the medial part of its posterior surface looks medially.

A considerable quantity of extraperitoneal fat gathers round the kidney, especially at its ends and borders. The extraperitoneal areolar tissue is slightly condensed to enclose the kidney and the suprarenal gland and a great part of the *renal fat* in a loose envelope called the *renal fascia*, and thin areolar strands pass from it through the fat to be attached to the fibrous capsule of the kidney. This envelope is very ill-defined in the cadaver unless special injection has been employed ; but, like many of the fascial layers, it is more definite in the living. Laterally and superiorly, its two layers unite with each other and fuse with the transversalis and diaphragmatic fasciæ. Inferiorly, they fail to unite, and are lost amidst the fat near the iliac crest. Medially also they fail to unite ; the posterior layer fuses with the fascia on the psoas ; and the anterior layer, passing medially, is lost in fat in front of the aorta. The fat inside the envelope is sometimes called the *perinephric fat*. The fat outside—most abundant behind the lower end of the kidney—is called the *paranephric fat*. (*Nephros* = kidney.)

Fixation.—The kidney is kept in place partly by its vessels, partly by the pressure of adjoining organs and partly by its fascia and fat. When a stout person becomes thin, the kidney is apt to slip down owing to the diminution of its fat (*movable kidney*) ; and, in rare cases, it may break away from the posterior wall and swing forwards in the abdomen (*floating kidney*)—a very dangerous displacement, for it may turn upside down, twisting its vessels and the ureter.

Variations.—Occasionally, the lower parts of the two kidneys are united by a thick band of kidney-substance which crosses in front of the aorta and inferior vena cava. Such a pair of kidneys is called a "horse-shoe kidney," and their ureters descend in front of the connecting band. Further, a kidney may be congenitally displaced, and may be found even in the pelvis, receiving its blood-supply from the iliac vessels.

Relations.—The *posterior relations* of the kidney are alike on the two sides. The bed on which the kidney lies is composed of muscles—the diaphragm, psoas major, quadratus lumborum (enclosed in lumbar fascia) and transversus abdominis. But certain structures intervene between it and the quadratus, namely—the subcostal vessels, the subcostal, ilio-hypogastric, and ilio-inguinal nerves.

The diaphragm separates the upper part of the kidney from the pleura—which is a very important posterior relation of the kidney—and, beyond the pleura, there are the twelfth rib and the muscles of the back. In some bodies (especially on the left side) there is a gap in the diaphragm above the twelfth rib near its free end (Fig. 190). At that point, the lateral

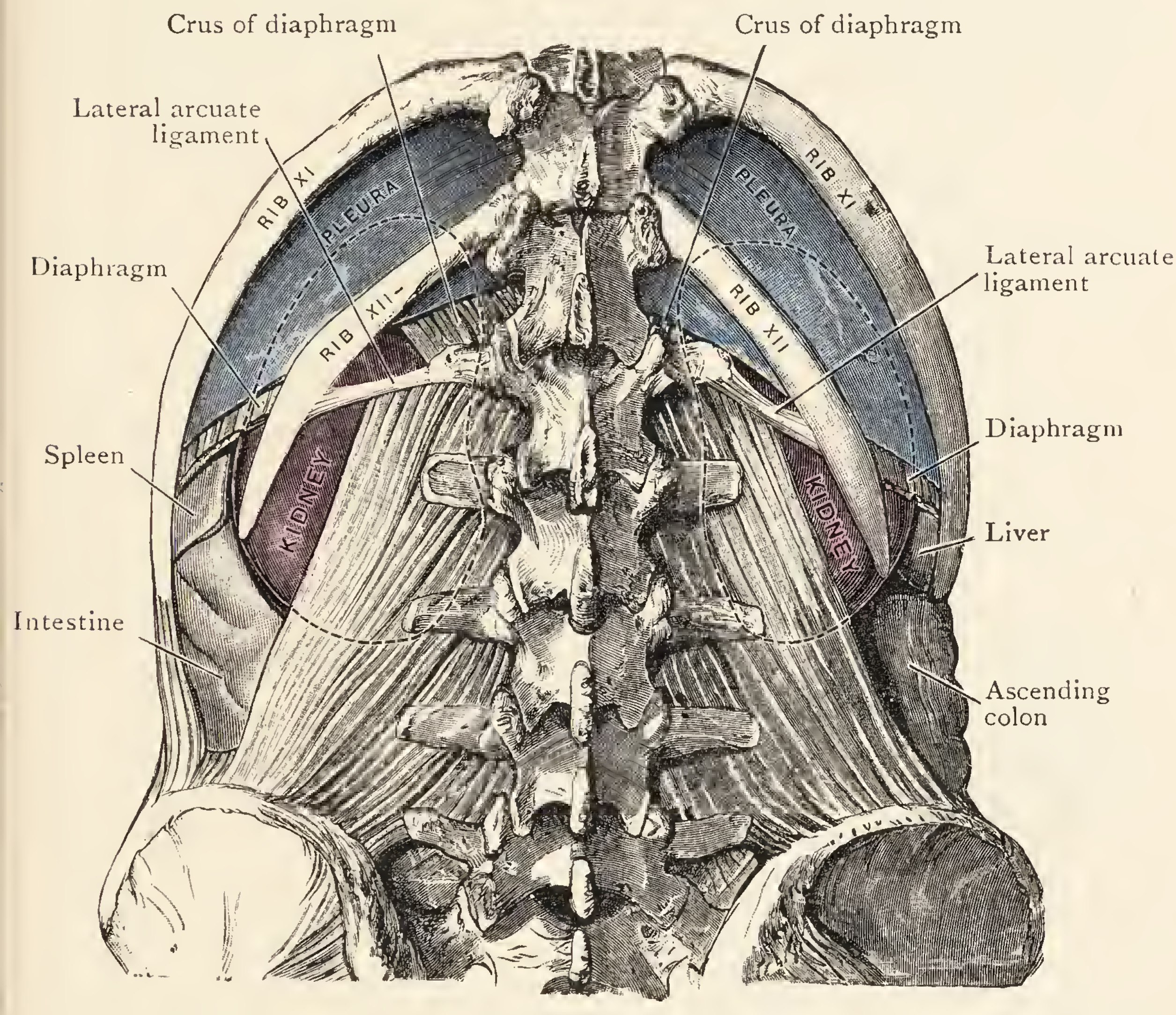

FIG. 184.—Dissection from behind to show the relation of the two Pleural Sacs to the Kidneys. The outline of the concealed portions of the kidneys (which are more alike in level than usual) is indicated by dotted lines.

part of the kidney is in very close relation with the pleura and the last rib—separated from them only by a little fatty tissue.

The lower and larger part of the kidney lies on the quadratus lumborum, and overlaps the psoas medially and the transversus laterally (Figs. 182, 184). The subcostal vessels and nerve lie on the quadratus lumborum near the last rib; and the ilio-hypogastric and ilio-inguinal nerves intervene between the muscle and the lower part of the kidney. To the operating surgeon, approaching the kidney from the back, the structures behind the quadratus are of importance (Fig. 195). They are the skin and fasciæ, the latissimus dorsi, the serratus posterior inferior, the lateral part of the sacro-spinalis, and small vessels and nerves.

Anteriorly, the **right kidney** is related to the suprarenal gland, the second part of the duodenum, the liver, the right flexure of the colon, a loop of the jejunum and the ascending branch of the right colic artery with its vein. The liver and

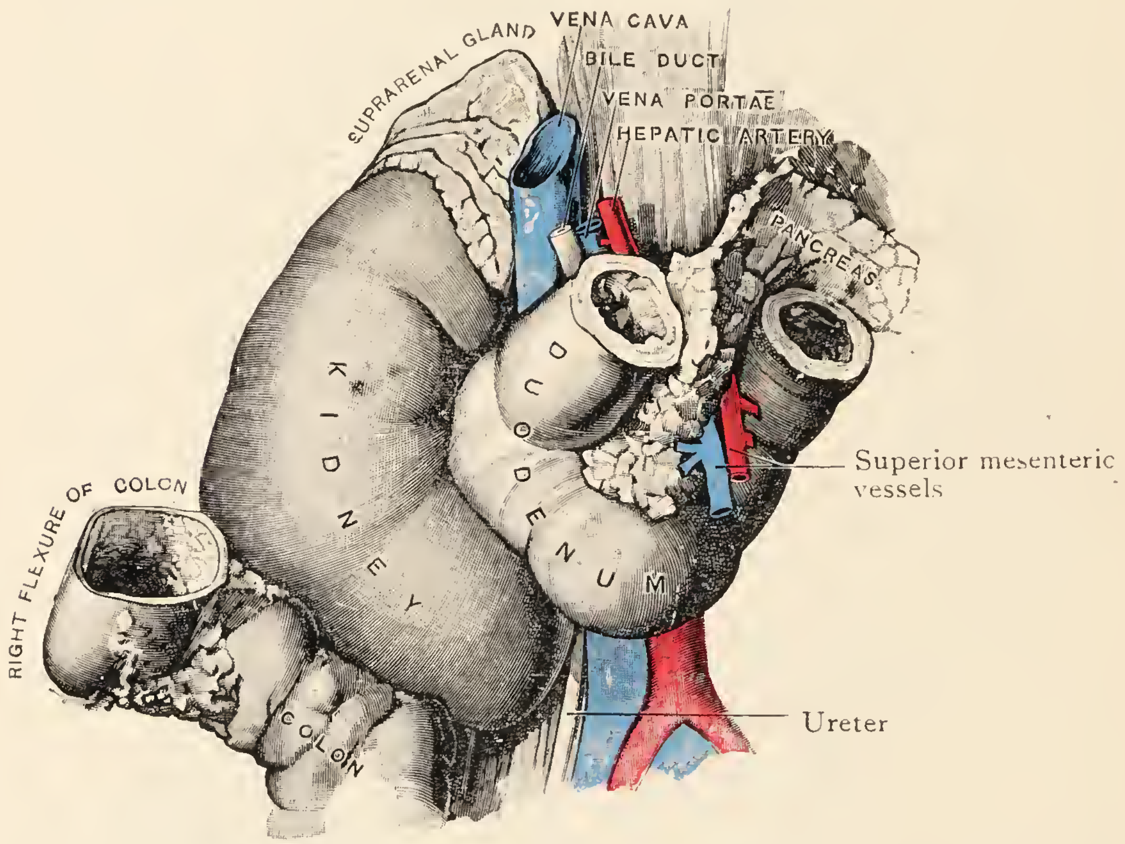

FIG. 185.—Right Kidney and Duodenum. The relation of the duodenum and the right flexure to the kidney is not so extensive as usual.

the jejunum are separated from it by peritoneum ; the other structures are in direct contact.

The suprarenal gland overlaps the upper end, especially towards the medial side. The duodenum overlaps it along the hilum. The right flexure covers a considerable part adjoining the lower end. Between the colon and the lower part of the duodenum, a small part at the lower end is related to the jejunum and is crossed by a branch of the right colic artery. The large area above the colon and lateral to the duodenum is hidden by the right lobe of the liver—which, indeed, overlies also the other structures named.

The **left kidney** is related *anteriorly* to a larger number of structures—the suprarenal gland, the stomach, the spleen and the lieno-renal ligament, the splenic vessels and the pancreas, the transverse colon, the descending colon, one or more loops of the jejunum, and the ascending branch of the upper left colic artery with its vein. The left kidney is therefore very inaccessible from the front. The stomach, the transverse colon and the jejunum are separated from it by peritoneum; the spleen is separated by peritoneum, but also is attached

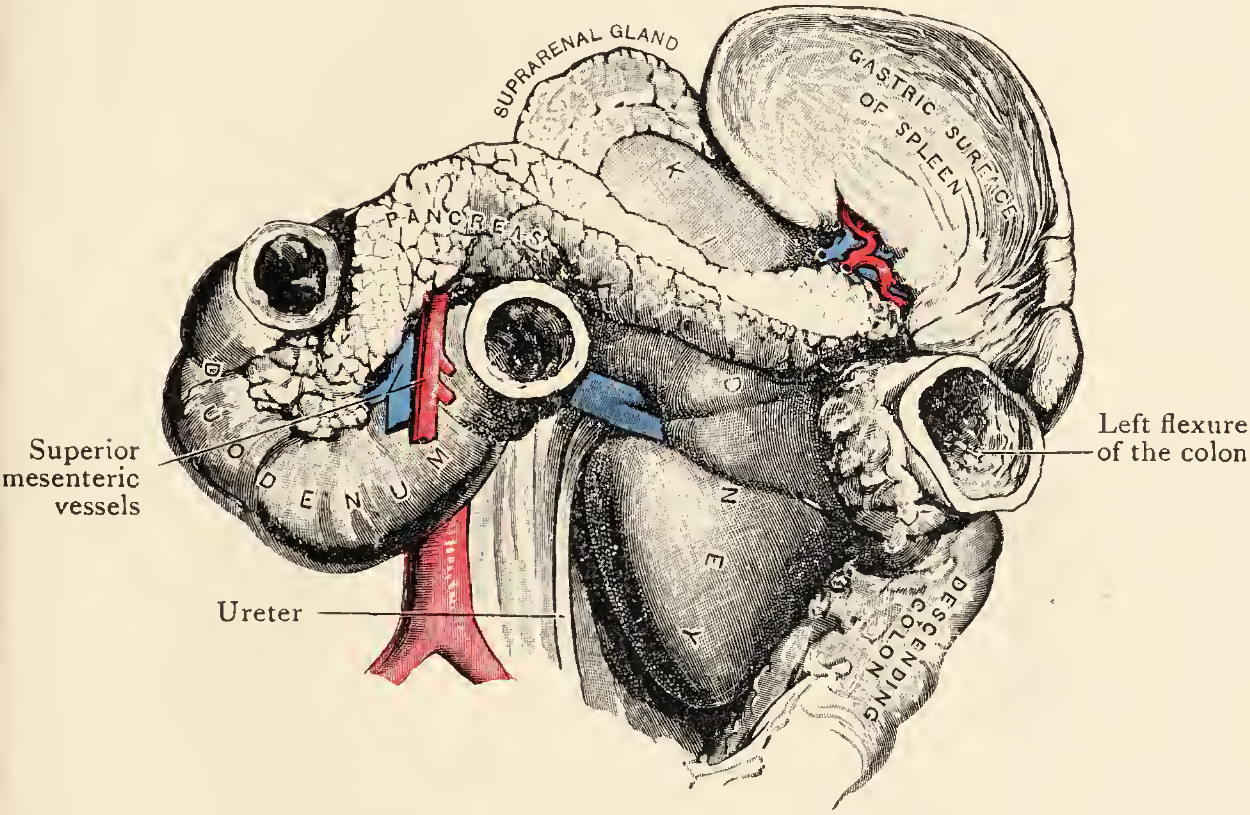

FIG. 186.—Relations of Left Kidney and Pancreas.

to it by the lieno-renal ligament; the other structures are in direct contact.

The suprarenal gland overlaps the upper, medial part. The spleen is related to a strip along the upper half of the lateral border, and the lieno-renal ligament is attached to the medial margin of that strip. The body of the pancreas lies across the kidney about the middle, with the splenic vein behind it and the splenic artery along its upper border. The stomach is related to the area bounded by the splenic artery, the spleen and the suprarenal gland. The left part of the transverse colon crosses the kidney immediately below the pancreas; and the descending colon overlaps the lower part of the kidney at its lateral border. The triangular area between these two parts of the colon is related to the jejunum and is crossed by the ascending branch of the upper left colic artery.

The dissectors will now examine the naked-eye structure of the kidney and the manner in which the ureter is formed.

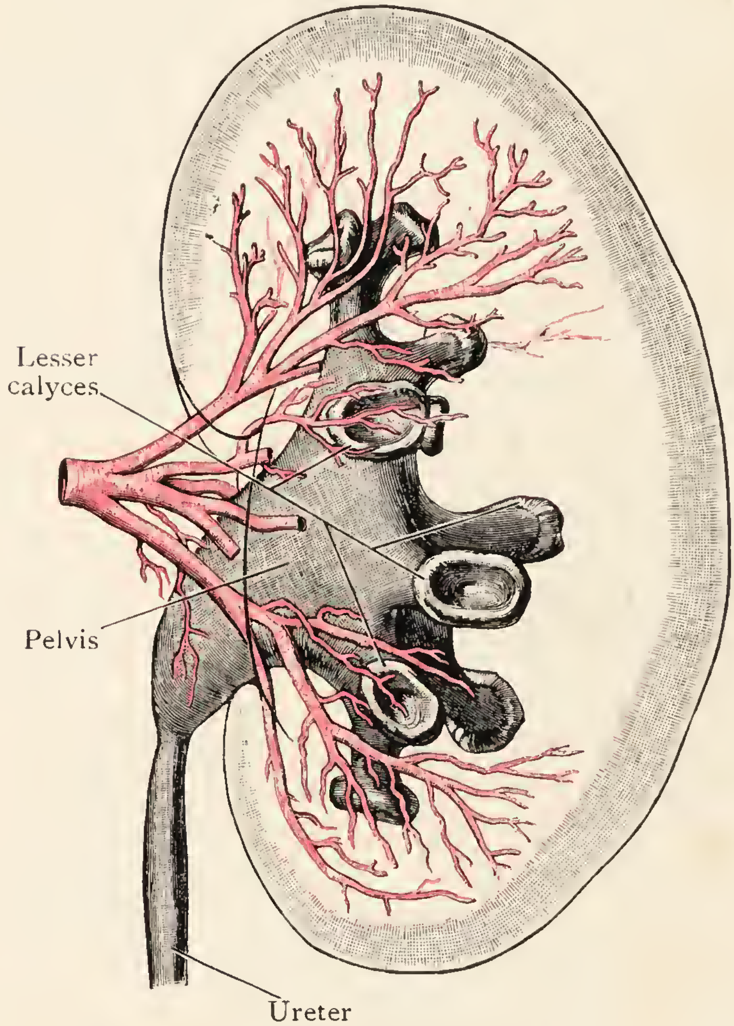

FIG. 187.—Pelvis of Ureter and Renal Artery (Max Brödel). The ureter and the arteries were injected with celloidin, and the kidney-substance then removed by a digesting fluid. The cupped appearance of each lesser calyx is due to the reflexion of its mucous coat over the renal papilla (Cf. Fig. 193).

Dissection.—Remove the anterior wall of the sinus piece-meal, beginning at the hilum; cut the vessels that enter the wall, and carefully separate the calyces of the ureter that are attached to it. Next, clean all the fat out of the sinus, but preserve the calyces and the vessels. Then, take a long-bladed knife and remove the anterior part of the kidney, making a clean cut from the ends and margins of the kidney to the bottom of the sinus.

Sinus of Kidney.—The first point to be noted when the kidney is cut is the extent of the sinus; it is a wide space, occupying a considerable part of the interior of the organ; it extends towards the ends of the kidney beyond the level of the ends of the hilum; and, before it is cleaned, it is filled with fat and with the ureter, nerves and vessels.

Vessels and Nerves of Kidney.—At or near the hilum, the *renal artery* divides into four or five branches. Most of them pass in front of the pelvis of the ureter, but one or two pass behind it; they divide further and sink through the walls of the sinus. Small veins emerge through the walls of the sinus and unite to form larger veins, which are mostly in front of the arteries but some are between the arteries and the ureter, and one or two may be behind the ureter. They pass out through the hilum and unite to form the *renal vein*. An *accessory renal artery* is not uncommon (p. 379.)

The *lymph-vessels* run with the veins and end in glands near at hand —alongside the aorta and vena cava (Fig. 194). The *nerves* spring from the cœliac and aortic plexuses and form the renal plexus, which sends off

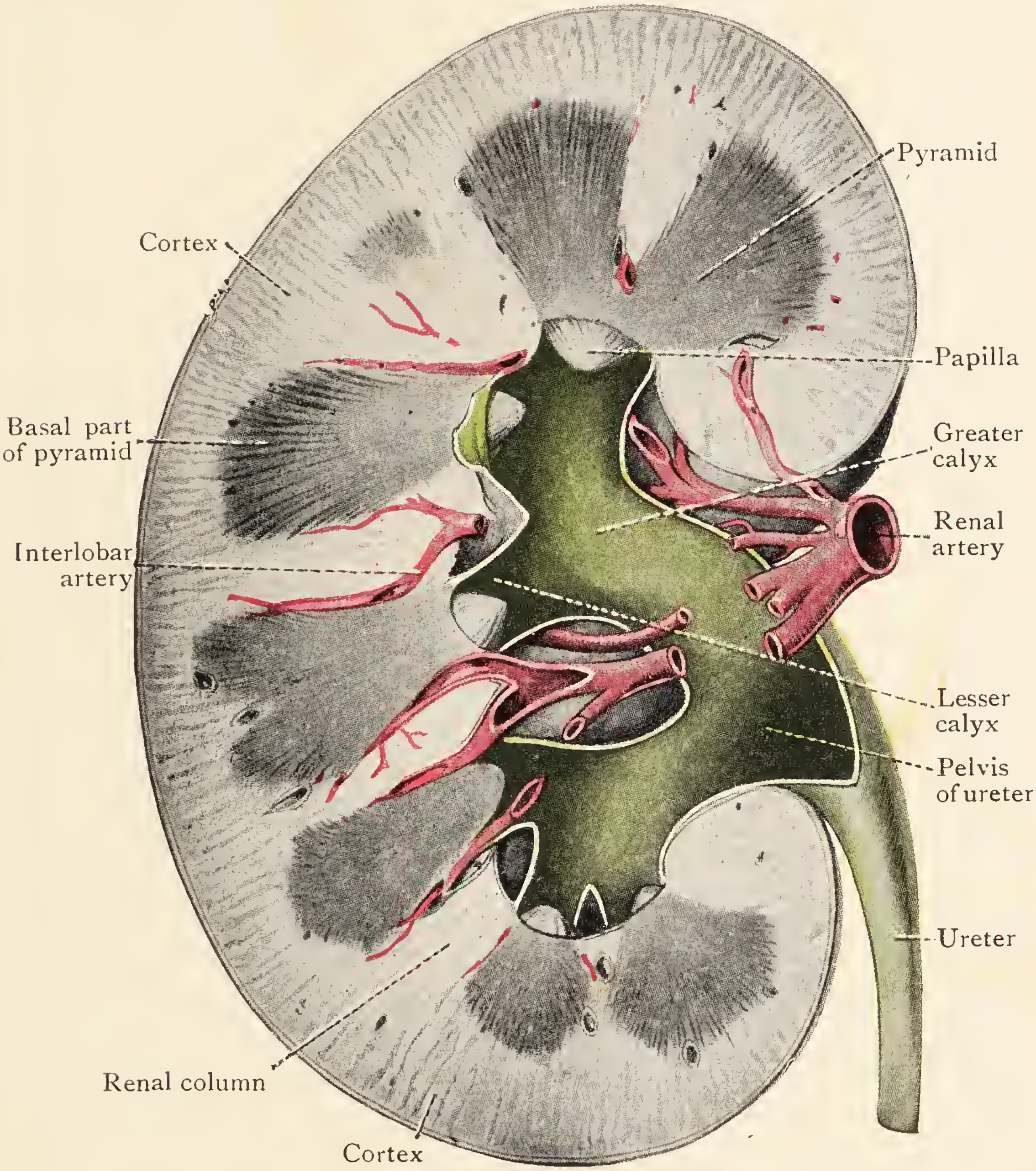

FIG. 188.—Coronal Section of Kidney. (A. F. Dixon)
The pelvis of the ureter and some of its calyces have been laid open.

filaments to accompany the branches of the artery into the kidney. They are derived ultimately from the medulla oblongata and from the last three thoracic segments of the spinal cord, and reach the plexuses through the vagi and the lower two splanchnic nerves.

Structure of Kidney (Fig. 188).—A glance at the renal vessels is enough to enable one to see that the kidney is a very vascular organ. Its substance is composed chiefly of minute arteries and veins and multitudes of microscopic epithelial tubules that convey the urine extracted from the blood towards the sinus, where the larger tubules open into the calyces of the ureter. And a glance at a section through the whole kidney will enable one to recognise that its substance is divisible into two main parts—a *cortex* next the surface and a *medulla* next the sinus. The cortex is uniformly granular or faintly streaked. The medulla is more striking. In it there are several dark-coloured masses, more or less triangular in outline, and streaked from base to apex. These are the *renal pyramids*. They are separated from one another by extensions of the cortical substance called *renal columns*, in which small arteries can be seen if the red injection has run well. The apical parts of the pyramids jut into the sinus as little nipples called the *renal papillæ*. The papillæ are grasped by the calyces of the ureter. Uriniferous tubules open on the summit of a papilla and pour the urine into a calyx.

The kidney is enclosed in a fibrous *capsule*, whose deep surface is connected with the network of areolar tissue that surrounds the tubules of the kidney. But the capsule is easily peeled off because the areolar tissue in the kidney is of very small amount. At the lips of the hilum the capsule passes into the sinus and lines its walls. At the base of each renal papilla, it is continuous with the fibro-muscular coat of the calyx.

Ureter.—The ureter is an expansile, muscular tube, whitish in appearance, ten inches long and about a quarter of an inch in diameter. It runs behind the parietal peritoneum—for the first half of its course in the abdomen proper and the second half in the true pelvis—and is so closely adherent to the peritoneum that it is stripped up with it. This relationship is of more importance in the true pelvis, where few structures intervene between the ureter and the peritoneum.

Origin and Course.—The ureter begins in the sinus of the kidney by the union of *calyces*. The commencement is dilated and is called the *pelvis of the ureter*. The pelvis emerges through the lower part of the hilum, and runs downwards along the medial border of the kidney, tapering to become the ureter proper near the lower end of the kidney. The *ureter proper* descends over the back wall of the abdomen, with a slight medial inclination, and it crosses the origin of the external iliac artery to enter the true pelvis. It is often slightly constricted where it springs from the pelvis, and where it crosses the external iliac artery. In radiographs, its shadow is usually seen opposite the tips of the lumbar transverse processes, though the ureteral catheter often displaces it (Fig. 193).

Calyces.—The calyces are of two kinds—lesser and greater (Fig. 188). The *lesser calyces*—about ten in number—are the short funnel-like tubes that embrace the renal papillæ and receive the urine. A lesser calyx may divide to grasp more than one papilla. The lesser calyces unite to form two *greater calyces*—an upper and a lower—which unite near the hilum to form the pelvis of the ureter.

Relations of Ureter.—Within the renal sinus, the pelvis and the calyces are surrounded by fat and the renal vessels.

Outside the kidney, both pelvis and ureter proper lie on the *psoas major* muscle. Until the ureter reaches the iliac artery the only structures that intervene between it and the muscle are a thin layer of fascia, the genito-femoral nerve and, when present, the tendon of the psoas minor.

The **right ureter** is a little lateral to the inferior vena cava. Its pelvis is covered by the second part of the duodenum and the renal vessels. The ureter proper is covered with peritoneum, but four sets of vessels cross in front of it, between it and the peritoneum, viz., the right colic, the testicular or ovarian, the ileo-colic, and the superior mesenteric in the root of the mesentery.

The **left ureter** is a little lateral to the inferior mesenteric vein. Its pelvis is more exposed than that of the right; after it escapes from behind the renal vessels, it is covered only by the peritoneum. But the ureter proper, as on the right side, is separated at intervals from the peritoneum by vessels—upper left colic, testicular or ovarian, and two or more lower left colic.

Dissection.—Cut out a small portion of the ureter, slit it open, and pin it down under water in the cork-lined tray. After it has soaked for some time, dissect its walls, stripping off layer by layer.

Structure and Vessels of Ureter.—The coats of the ureter are:—(1) an outer *adventitious coat* of fibrous tissue; (2) a *muscular coat* of non-striped muscle mixed with fibrous tissue, in three thin layers; (3) a very thin *submucous coat*; (4) a *mucous coat*, thrown into longitudinal folds when the ureter is empty.

The *blood-vessels* are minute twigs from the various vessels to which the ureter is related. The *lymph-vessels* pass to the aortic, common iliac or internal iliac glands, according to the part from which they arise.

The study of the viscera of the abdomen proper is now completed, and the dissectors will direct their attention to the diaphragm.

Dissection.—Strip the peritoneum off the *diaphragm*, avoiding injury to the phrenic vessels. Define the *crura*, and clean them, but retain the vessels that cross them. Then, carefully define the *arcuate ligaments*, which arch across the psoas and the quadratus lumborum where they disappear behind the diaphragm. Lastly, on one side, detach the slips of the transversus abdominis from the costal cartilages, define the slips of the diaphragm, and secure the nerves and vessels that pass from the thorax into the abdomen between the slips.

Diaphragm.—The diaphragm is the chief muscle of respiration and is therefore the most important muscle in the body—next after the heart. It is a thin, movable partition between the cavities of the thorax and abdomen, forming a concave roof for the abdomen and a convex floor for the thorax. It has been explained in the introduction to the Thorax that there are two types of respiration—thoracic and abdominal (p. 4). It is in the abdominal type that the

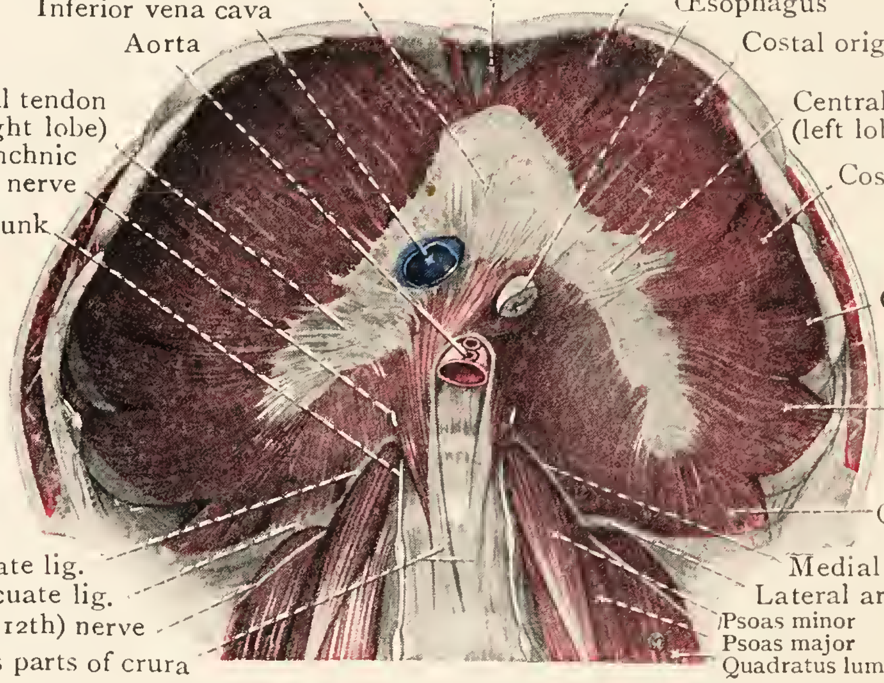

FIG. 189.—Semi-diagrammatic View of Diaphragm.

diaphragm plays its part. With every breath, it descends and rises again, and in that way the capacity of the thorax is alternately increased and decreased in its vertical diameters. It has been noted before that the vault of the diaphragm is higher on the right side than on the left, and that in ordinary expiration it is only a little below the nipple on each side; but in forced expiration the left cupola rises to the level of the nipple and the right reaches the level of the rib above the nipple—the fourth (Fig. 24).

Central Tendon.—The central part of the diaphragm is aponeurotic and exceedingly strong, and it is called the **central tendon.** Its tendinous bundles run in different directions, and, interlacing with one another, give it a pleated appearance. In outline, it is an uneven and sharply-curved semilune with the concavity directed backwards. The median part is wide and is called the *median lobe*; the horns are the *right* and *left lobes*, of which the left is the narrower.

Attachments.—The diaphragm takes origin at its circumference from the margins of the outlet of the thorax; and, from the origin, the fleshy bundles curve upwards and inwards from every side to be inserted into the edges of the central tendon.

The fleshy part of the diaphragm is divided into three parts—sternal, costal and vertebral.

The **sternal part** is very short and narrow, and is merely

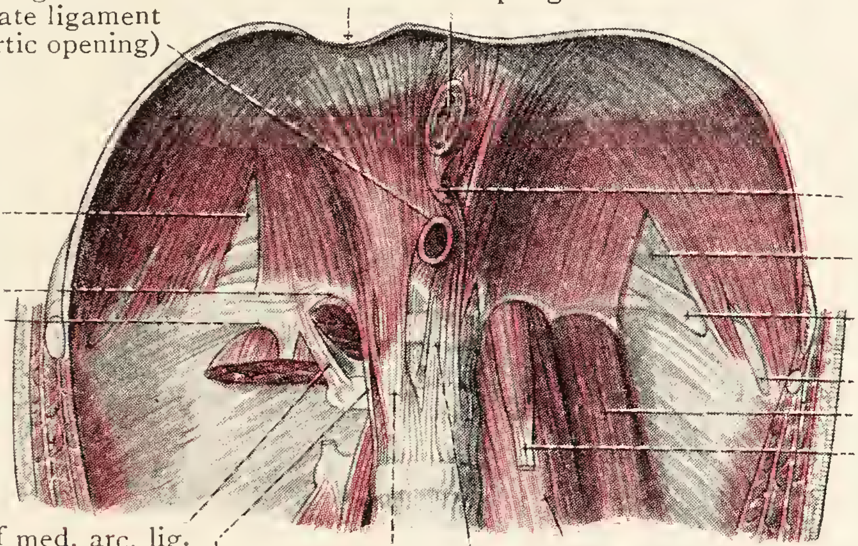

FIG. 190—Dissection showing Posterior Origin of Diaphragm. From a specimen in which the Vertebro-Costal Triangles were well-marked.

a pair of small slips that spring from the back of the xiphoid process; the right is separated from the left by a little areolar tissue.

The **costal part** is very extensive, but it rises so steeply at first that, in a drawing of the diaphragm from above or below, its lower part is greatly foreshortened. On each side, it arises from the inner surfaces of the lower six costal cartilages, along a zigzag line, by six wide, oblique slips—the corresponding slips of the transversus abdominis fitting into the shallow angles of the line.

The **vertebral part** takes origin from the upper lumbar vertebræ by means of a pair of *crura*, and also, on each side, from two *arcuate ligaments* that are connected with these vertebræ (Fig. 190).

Crura.—Each crus is a thick, fleshy bundle that tapers inferiorly into a tendinous funnel out of which fleshy fibres proceed; and its attachment to the vertebral bodies is interrupted by the passage of upper lumbar arteries between the crus and the bone. The *left crus* is attached to the anterior surface of the upper two lumbar vertebræ and the intervening disc. The *right crus* is thicker and longer, and is attached to the upper three vertebræ and the intervening discs. The fleshy fibres of the crura spread out and ascend to reach the central tendon—the fibres of the right crus encircling the œsophagus on their way.

Arcuate Ligaments.—Opposite the last thoracic vertebra, the two crura are united to each other by a tendinous band called the *median arcuate ligament*, from which a few fibres of the diaphragm arise. This band arches across the aorta as it enters the abdomen, and exemplifies the rule that where an artery passes through the bony attachment of a muscle it is protected by a tendinous arch.

The medial and lateral arcuate ligaments are tendinous bands that extend the vertebral attachment of the diaphragm across the upper parts of the psoas major and quadratus lumborum. They are tendinous parts of the diaphragm, but they are fused with the fascia that covers the psoas and quadratus as these muscles pass behind the diaphragm. The *medial arcuate ligament* is highly arched; it springs from the tendinous part of the crus, curves across the front of the psoas, and then dips backwards across its lateral side to be attached to the tip of the first or the second lumbar transverse process. The *lateral arcuate ligament* stretches across the quadratus lumborum from the tip of that process to the last rib. The portion of the diaphragm that arises from the lateral ligament is very thin, and is overlapped by the costal part near the central tendon; it varies in width—its origin frequently failing to extend as far as the costal end of the ligament.

Foramina in Diaphragm.—The continuity of the diaphragm is broken by three large apertures and several smaller ones. The three main openings are the aortic, the œsophageal and the vena caval.

The **aortic opening** is in the median plane in front of the lower border of the twelfth thoracic vertebra, between the crura, and behind the median arcuate ligament. It transmits the aorta, the azygos vein on the right of the aorta, the thoracic duct between those two, and a pair of lymph-vessels that descend from the thorax to the cisterna chyli—which is the receptacle for lymph from which the thoracic duct arises.

The **œsophageal opening** is an oval aperture placed obliquely behind the central tendon, surrounded by fleshy bundles which constrict it and prevent regurgitation of food when the contracting diaphragm descends and exerts pressure on the abdominal contents. The opening transmits the œsophagus, the gastric nerves, and the œsophageal branches of the left gastric vessels. It is about one inch to the left of the median plane opposite the seventh costal cartilage, at the level of the body of the tenth thoracic vertebra—*i.e.* at the level of the ninth spine. But its position is variable: it may be in the median plane or even to the right of it; and it may be fairly close to the aortic opening.

The **vena caval opening** is a wide opening about one inch to the right of the median plane opposite the sixth costal cartilage at the level of the body of the eighth thoracic vertebra and of the seventh spine (but may be lower). It is in the central tendon between the right and median lobes —which ensures that it is stretched when the diaphragm contracts, thus facilitating the flow of venous blood into the thorax that takes place with every inspiration. It transmits the inferior vena cava, slender branches of the right phrenic nerve, and a few lymph-vessels from the liver.

Numerous smaller structures pass between the thorax and the abdomen—some of them through the diaphragm and some behind it. They are:—

1. The superior epigastric vessels, between the sternal and costal origins.
2. The musculo-phrenic vessels, between the slips from the seventh and eighth cartilages.
3. The lower five intercostal nerves (accompanied by small vessels), between the slips—from the seventh cartilage downwards.
4. The subcostal vessels and nerve, behind the lateral arcuate ligament.
5. The sympathetic trunk, behind the medial arcuate ligament, at the anterior edge of the psoas.
6. The three splanchnic nerves, piercing each crus.
7. The inferior hemiazygos vein, piercing the left crus.

The interval between the sternal and costal parts of the diaphragm is larger than is necessary for the passage of the superior epigastric vessels. At this triangular gap the pleura and the peritoneum are separated only by a little loose areolar tissue.

Vertebro-Costal Triangle (Fig. 190).—This is a more important triangular gap found in many bodies between the vertebral and costal attachments, above the lateral part of the last rib behind the kidney; but it does not transmit any structure. When it is present the pleura is separated from the renal fat by a little areolar tissue only. It is usually larger on the left side, and is more often present on that side. It is the remains of an interval that existed between parts of the diaphragm of different developmental origin, and through which the peritoneal and pleural cavities were originally continuous; its practical importance is that, on the left side, some of the contents of the abdomen may be herniated through it into the thorax.

Nerves and Vessels of Diaphragm.—The chief *nerves* are the phrenic, which derive their fibres from the third, fourth and fifth cervical (chiefly the fourth)—the high origin of the nerves being accounted for by the fact that the diaphragm (like the heart) began its development in the neck and gradually descended. It may receive twigs (probably sensory) also from the lower intercostal nerves; and it receives a sympathetic supply through the branches of the cœliac plexus that accompany the phrenic arteries.

The *arteries* are from various sources:—the phrenic from the abdominal aorta; irregular branches from the thoracic aorta; twigs from the musculo-phrenic and the lower intercostals; and a pair of very long, slender arteries—pericardiaco-phrenic—that accompany the phrenic nerves from the root of the neck.

Vessels on Posterior Wall of Abdomen

Dissection.—Clean the *abdominal aorta* and its branches and the *inferior vena cava*, and look for lymph-glands alongside the aorta. As the dissection proceeds, clean also the *sympathetic trunks* and secure their branches. Each trunk lies along the anterior edge of the psoas (the right one being behind the vena cava). Dissect the trunks carefully. Follow the *lumbar arteries* till they disappear under cover of the psoas. Separate the right crus of the diaphragm from the aorta, and dissect in the interval between them. The *cisterna chyli* and the *vena azygos* will be found there; clean the cisterna, and follow the azygos vein downwards. Trace the *testicular* (or *ovarian*) arteries from above downwards.

Abdominal Aorta.—The abdominal part of the descending aorta is the direct continuation of the thoracic part. It begins in the median plane, at the aortic opening of the diaphragm, in front of the lower border of the last thoracic vertebra ; and it ends on the front of the lower part of the body of the fourth lumbar vertebra, a little to the left of the median plane, by dividing into the two *common iliac arteries*. It pursues, therefore, an oblique course—inclining slightly to the left as it proceeds downwards. A line drawn between the highest points of the iliac crests gives the level of the bifurcation of the abdominal aorta, which is indicated also by a point a little below and to the left of the umbilicus.

Relations.—Most of the structures which lie *in front of* the abdominal aorta have been removed. The cœliac and aortic plexuses are in the most intimate relation. But in close relation also there are the following, from above downwards :—(1) the pancreas and splenic vein ; (2) the left renal vein ; (3) the third part of the duodenum ; (4) the root of the mesentery and the superior mesenteric vessels ; (5) the peritoneum, which separates its lower part from the small intestines. More superficially it is covered by :—the lesser omentum ; the liver ; the stomach ; the transverse colon and mesocolon ; and by the greater omentum. It should be noted that the lowest part of the aorta is separated from the anterior wall of the abdomen only by a coil or two of the small intestine and the greater omentum. In the recumbent position, when the anterior wall is retracted, there is very little interval between the anterior wall and the aorta ; in a thin person, the pulsations of the aorta can be seen, and it can be compressed against the backbone by firm pressure exerted on the anterior abdominal wall.

Behind, the abdominal aorta rests upon the bodies of the lumbar vertebræ and the intervertebral discs, separated from them, however, by the anterior longitudinal ligament and by the third and fourth lumbar veins of the left side.

On each side, it is related, in its upper part, to the crus of the diaphragm ; and, in its lower part, the sympathetic trunk is only a little distance away. *On the right side*, the inferior vena cava lies close to the aorta as high as the second lumbar vertebra, but above that it is separated from the aorta by the fleshy part of the right crus. In the interval between the right crus of the diaphragm and the aorta, the dissectors have already noted the cisterna chyli and the vena azygos. *On the left side*, it is related to the fourth part of the duodenum and to coils of the jejunum below the level of the crus.

Branches of Abdominal Aorta.—The branches are classified under two heads—*single* and *paired*.

Single Branches	Paired Branches
1. Cœliac.	1. Phrenic.
2. Superior mesenteric.	2. Middle suprarenal.
3. Inferior mesenteric.	3. Renal.
4. Median sacral.	4. Testicular or ovarian.
	5. Lumbar (four pairs).

With the exception of the *median sacral*, which arises from the back of the extremity of the aorta and runs into the true pelvis (p. 434), the *single branches* have already been described. The *paired branches* may now be examined.

Phrenic Arteries.—These are the first branches which spring from the abdominal aorta, and they have already been noticed on the under surface of the diaphragm. As they proceed upwards and forwards, they diverge from each other, and each passes close to the cœliac ganglion and the suprarenal gland ; the right artery crosses behind the inferior vena cava, the left behind the œsophagus ; and they ramify on the lower surface of the diaphragm. Besides supplying branches to the diaphragm, each phrenic artery sends a twig (or more than one), called the *superior suprarenal artery*, to the suprarenal gland.

Phrenic Veins.—The *right vein* opens into the inferior vena cava ; the *left* may do so also, or it may run downwards and end in the left suprarenal vein.

Middle Suprarenal Arteries.—These are a pair of very small arteries that arise near the origin of the superior mesenteric. Each runs laterally and upwards, in front of a crus of the diaphragm, behind or through the cœliac ganglion, to reach the suprarenal gland. The right passes behind the inferior vena cava also. Occasionally they are so small that they cannot be found.

Suprarenal Veins.—There is only one on each side. The *right vein* opens into the inferior vena cava, but the *left suprarenal vein* descends to the left renal vein.

Renal Arteries.—These wide arteries take origin from the sides of the aorta about a quarter of an inch below the level of the superior mesenteric, opposite the second lumbar vertebra. Each passes laterally across the crus of the diaphragm and the psoas muscle to reach the kidney, where its renal branches have been examined already. Near the kidney, it gives small branches to the ureter, and sends up a small branch, called the *inferior suprarenal artery*, to the suprarenal gland.

The *left* renal artery is behind its own vein ; the *right* is behind its own vein and the inferior vena cava and the end of the left vein.

Renal Veins.—The renal veins run in front of their arteries to join the sides of the inferior vena cava. As the vena cava is near the right kidney, the **right** vein is short ; it is covered by the second part of the duodenum, and, sometimes, by the lateral margin of the head of the pancreas. The **left** vein has to cross the median plane to reach the vena cava and is therefore much longer. It runs in front of its artery, crosses the aorta immediately below the root of the superior mesenteric artery, and ends in front of the left renal artery. Till it reaches the aorta, it may be behind the pancreas, or behind the peritoneum below the pancreas ; the part of it to the right of that is behind the pancreas. As it approaches the aorta, the inferior mesenteric vein passes upwards in front of it ; and as it crosses the aorta, the superior mesenteric artery descends in front of it. Near the kidney, the left testicular or ovarian vein joins its lower border ; and the left suprarenal vein joins its upper border nearer the median plane.

Accessory Renal Artery.—This vessel is not uncommon, especially on the left side. It usually arises from the lower part of the aorta, crosses in front of the ureter and enters the kidney through the lower part of its anterior surface. But the origin varies ; and there may be more than one accessory renal artery.

Testicular and Ovarian Arteries.—The **testicular arteries** are a pair of long, slender vessels which spring from the front of the abdominal aorta a short way below the renal arteries. Diverging from its fellow, each artery passes obliquely downwards and laterally over the posterior wall of the abdomen to the deep inguinal ring, where it enters the inguinal canal. The **right** artery rests on the inferior vena cava and the psoas, and, at the lower part of the abdomen, on the external iliac artery. As it lies on the psoas, it crosses the ureter, and is crossed by the duodenum, and the right colic, ileo-colic and superior mesenteric vessels. The **left** artery crosses the sympathetic trunk to reach the psoas ; as it descends over the psoas it crosses the ureter ; and it leaves the psoas to lie on the external iliac artery. It is crossed by the duodenum, the inferior mesenteric vein, and the left colic vessels ; and an important anterior relation is the terminal part of the descending (iliac) colon, which crosses both the testicular and the external iliac vessels.

The **ovarian artery** is the corresponding vessel in the female. It has the same origin, and the same course and relations down to the point where it reaches the external iliac artery ; it crosses that artery an inch below its origin, and enters the true pelvis, where it will be dissected later.

Testicular and Ovarian Veins.—The *testicular vein* arises from the pampiniform plexus at or near the deep inguinal ring, and accompanies the artery in the abdomen. The *left* vein ends in the left renal ; the *right* vein ends in the inferior vena cava a little below the level of the renal vein.

The *ovarian vein* arises at the pelvic brim from a pampiniform plexus that surrounds the ovarian artery in the pelvis ; it accompanies the artery in the abdomen and ends—the *left* in the left renal vein, the *right* in the inferior vena cava.

Lumbar Arteries.—The lumbar arteries are four pairs of arteries that spring from the back of the abdominal aorta in series with the intercostal arteries. At present only portions of them are visible, and they will be studied after their dissection is completed.

Vena Cava Inferior.—The inferior vena cava is the widest vein in the body and one of the longest. It collects the venous blood from the lower limbs, from a great part of the abdominal parietes and from all the abdominal viscera—much of the visceral blood having passed through the liver from the portal vein.

Origin, Course and Termination.—It is formed by the union of the two *common iliac veins*, to the right of the median plane, on the front of the fifth lumbar vertebra and behind the right common iliac artery (Fig. 191). It ascends over the posterior wall of the abdomen about one inch to the right of the median plane, first on the vertebral bodies and the psoas major and next on the posterior part of the diaphragm, where it is deeply embedded in the back of the liver; it pierces the central tendon of the diaphragm and the pericardium, and ends in the lower and posterior part of the right atrium of the heart.

Relations.—The right sympathetic trunk lies lengthwise *behind* it, along the medial margin of the psoas; the lower right lumbar arteries intervene between it and the vertebral bodies. Several structures intervene between it and the diaphragm:—the right renal artery at the level of the second vertebra; the right cœliac ganglion, middle suprarenal artery and medial part of the suprarenal gland at the level of the first; and the right phrenic artery at a still higher level.

Its *anterior* relations are more numerous. After it emerges from behind the right common iliac artery, it is crossed by the root of the mesentery and the superior mesenteric vessels. For a short distance above the root of the mesentery it is immediately behind the peritoneum and is crossed by the ileo-colic and right colic vessels. At the level of the third lumbar vertebra it is crossed by the third part of the duodenum and the right testicular or ovarian artery. Next, the head of the pancreas is in front of it, and the bile-duct descends in front of its lateral border. Above the head of the pancreas it passes behind the first part of the duodenum, from which it is separated by the portal vein; it then ascends behind the opening that leads into the lesser peritoneal sac; and, finally, the liver is in front of it; but, since it lies in a deep groove on the back of the liver, parts of the liver are on its right and its left as well as in front.

On its left side, from below upwards, there are the aorta, the right crus, and the caudate lobe of the liver; *on its right side*, the ureter, the kidney, the suprarenal gland, and the bulk of the right lobe of the liver.

Tributaries.—It receives the following veins:—

1. Common iliac veins.
2. Third and fourth lumbar veins.
3. Right testicular or ovarian vein.
4. Renal veins.
5. Right suprarenal vein.
6. Phrenic veins.
7. Hepatic veins.

Common Iliac Arteries.—The common iliac arteries are the terminal branches of the aorta. They arise on the front of the body of the fourth lumbar vertebra to the left of the median plane, and, diverging from each other, proceed downwards and laterally on the vertebral column. After a course of about two inches, each vessel ends opposite the corresponding sacro-iliac joint, at the level of the lumbo-sacral intervertebral disc, by dividing into *external iliac* and *internal iliac* (hypogastric) arteries ; the external iliac is the

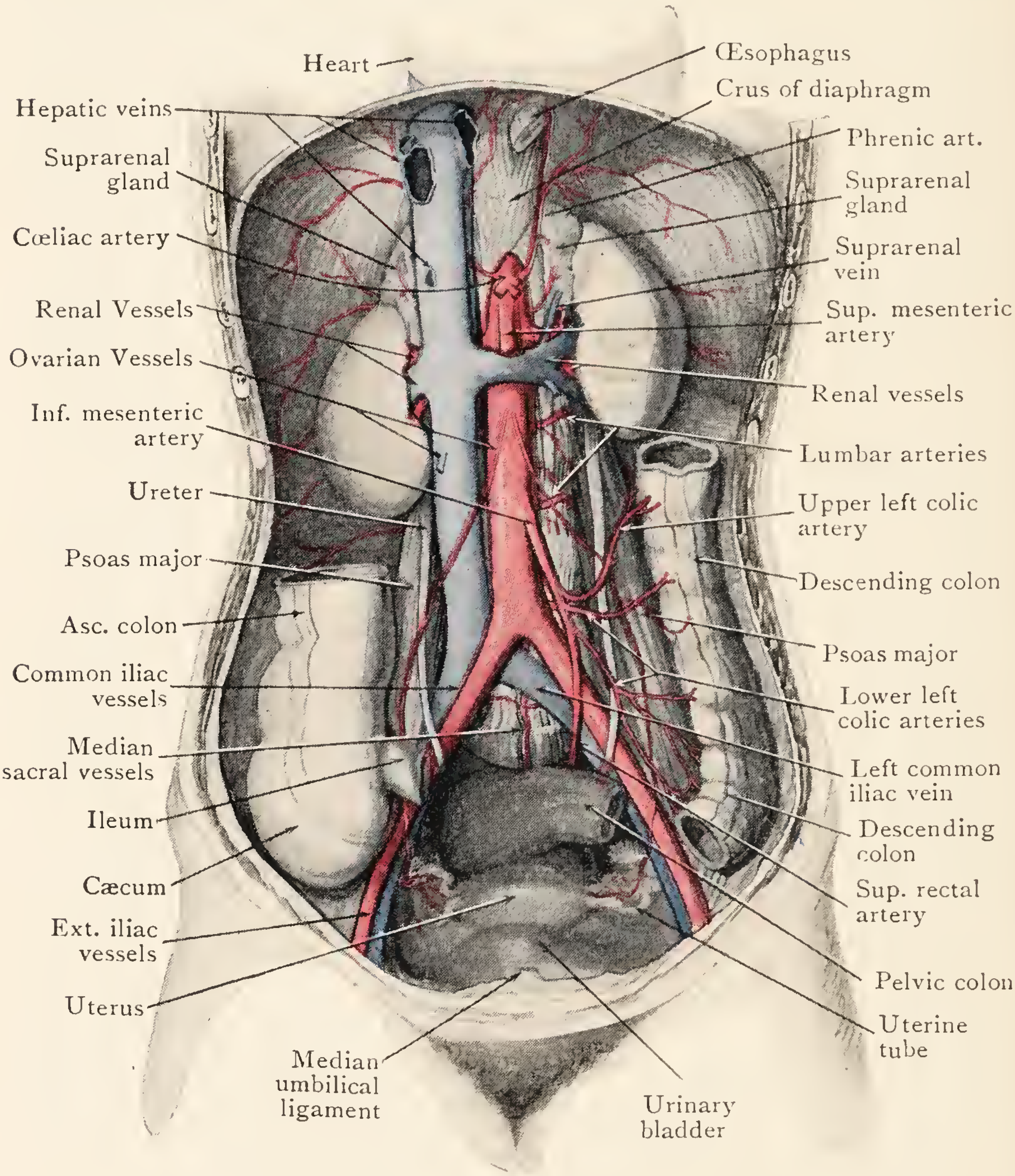

FIG. 191.—Inferior Vena Cava and its Tributaries.

larger of the two branches and appears to be the continuation of the parent trunk ; the internal iliac, which was the original continuation, passes backwards and slightly downwards into the true pelvis.

The common iliac arteries have no branches of any consequence except their terminal branches.

Relations.—The **right** artery lies on the commencement of the inferior vena cava and on its own vein. It is covered with the peritoneum and is crossed near its origin by a branch or branches proceeding from the right sympathetic trunk to the hypogastric plexus.

The **left** artery lies on the fourth and fifth lumbar vertebræ, the sympathetic trunk, and the medial margin of the psoas major. It is covered with peritoneum and is crossed by branches from the left sympathetic trunk to the hypogastric plexus, by the superior rectal vessels in the medial limb of the pelvic mesocolon, and by one or two lower left colic vessels.

Common Iliac Veins.—Each common iliac vein begins on the medial surface of the psoas, above and behind the internal iliac artery, by the union of the external and internal iliac veins, and it ends on the front of the fifth lumbar vertebra, an inch to the right of the median plane, by uniting with its fellow to form the inferior vena cava.

Tributaries.—Besides the two veins that form it, each of them receives the ilio-lumbar vein, which enters the back of it ; and the left vein receives the median sacral vein also.

Relations.—The **right** vein is behind its own artery in front of a mass of fat that contains the sympathetic trunk, the ilio-lumbar artery, and a thick nerve-cord called the lumbo-sacral trunk.

The **left** vein is much longer, for it has to cross the median plane. It is below and medial to its artery. It lies first on the fat that contains the sympathetic trunk, and then on the fifth lumbar vertebra, where the median sacral artery descends behind it. It is covered with peritoneum but is partly separated from it by the hypogastric plexus and by the vessels that cross the left common iliac artery.

External Iliac Arteries.—The external iliac arteries are the abdominal portions of the great arterial trunks which carry blood to the Lower Limbs. Each begins opposite the corresponding sacro-iliac joint at the level of the lumbo-sacral intervertebral disc, and extends obliquely downwards and sidewards along the brim of the true pelvis to the mid-inguinal point, where it passes behind the inguinal ligament into the thigh and becomes the *femoral artery*.

Branches.—It has only two branches—the inferior epigastric and the deep circumflex iliac. They arise from it immediately above the inguinal ligament, and were examined when the anterior wall of the abdomen was dissected.

Relations.—The external iliac artery lies first on the medial surface of the psoas, and then on the front of the muscle. Its vein is behind its upper part, and along the medial side of its lower part. Its superficial surface is covered with peritoneum; but a number of structures intervene between it and the peritoneum. These structures are slightly different in the two sexes; and, in each sex, they are more numerous on the left side.

On the **right side**, the ureter crosses the origin of the artery; at its lower end, the vas deferens and the deep circumflex iliac vein cross it behind the root of the inferior epigastric artery. The testicular artery and genito-femoral nerve are lateral to the upper part of the artery; the femoral branch of the nerve remains on its lateral side, but the genital branch and the artery pass on to the front of the lower part. In the female the relations are the same, except that the ovarian artery crosses the external iliac an inch below its origin, and the round ligament of the uterus takes the place of the vas deferens. On the right side, though the cæcum overlaps the artery, and the appendix and the ileum cross it, note that it is separated from them by peritoneum.

On the **left side**, the same structures intervene between the artery and the peritoneum; but, in addition, the artery is crossed by the lowest left colic vessels and also by the terminal (iliac) part of the descending colon, which is in direct contact with the artery.

External Iliac Veins.—Each external iliac vein is the continuation of the corresponding femoral vein and begins behind the inguinal ligament. In its ascent, it is first on the front of the psoas and then on its medial surface; and it is first on the medial side of the artery and then behind it. Its superficial surface is covered with peritoneum, and it is related to the same structures as the artery; but its terminal part passes lateral to the upper part of the internal iliac artery to reach the internal iliac vein, with which it unites to form the common iliac vein.

Tributaries.—Its tributaries are the companion veins of the two branches of the artery—inferior epigastric and deep circumflex iliac—and they enter it very near its lower end.

Deep Lymph-Glands.—The glands of the posterior wall of the abdomen are arranged in chains along the external and common iliac vessels, the aorta and the inferior vena cava (Figs. 194 and 219).

PLATE XXI

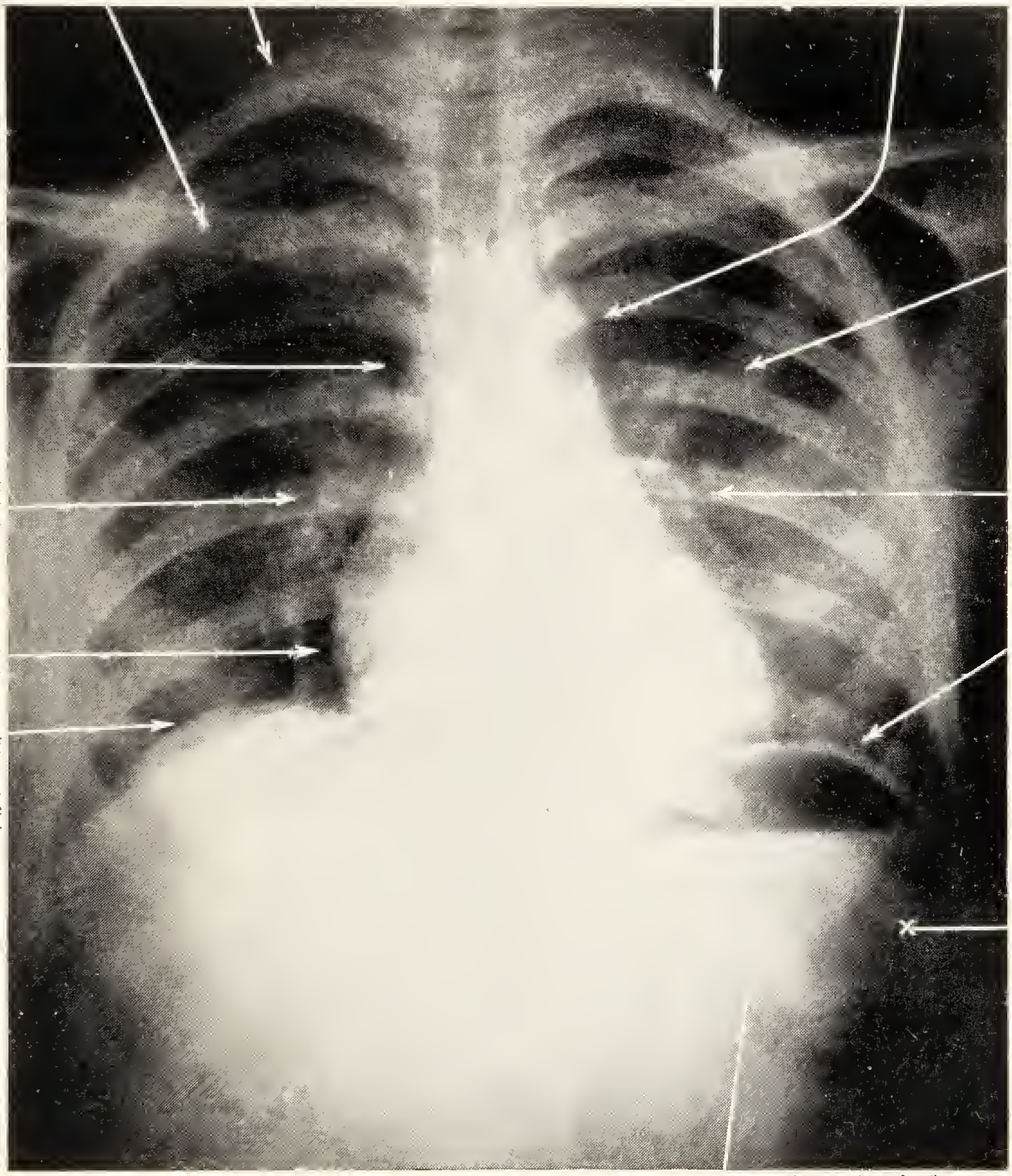

FIG. 192.—Radiograph of Thorax and Upper Abdomen of youth aged 18, to show the position of the Diaphragm in Semi-Inspiration, and the relation of Abdominal to Thoracic Organs. See also Figs. 8 and 24.

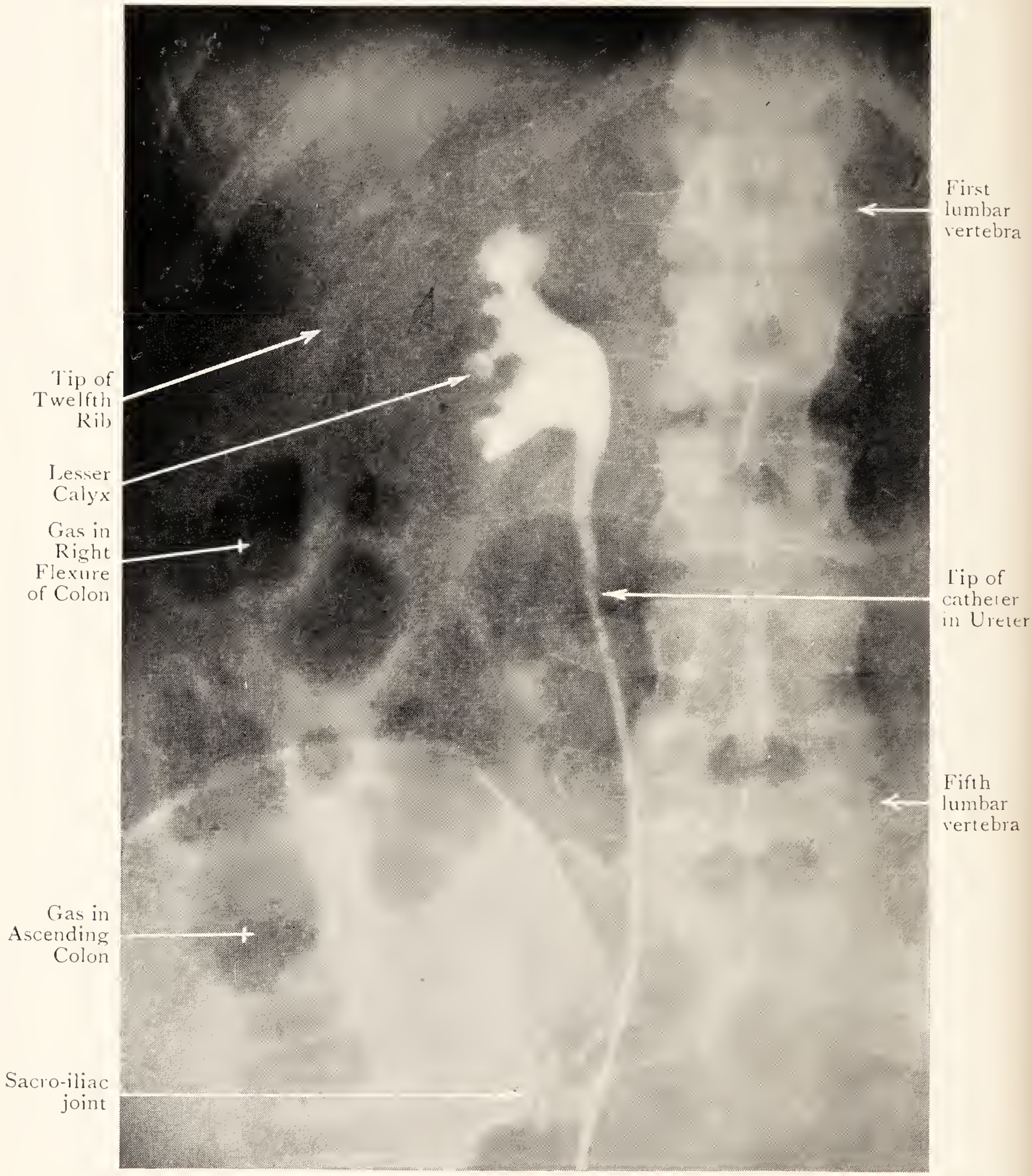

FIG. 193.—Radiograph of Right Ureter of man aged 44, after the passage of a ureteral catheter and the injection of a radio-opaque solution into its Pelvis and Calyces.

(Dr. J. F. Brailsford)

Note the division of the pelvis into two greater calyces, and the appearance of a lesser calyx. Cf. Fig. 188. The resilience of the catheter has displaced the lower part of the abdominal portion of the ureter medially. The outlines of the Kidney, the 11th and 12th Ribs, and the transverse processes of the Lumbar Vertebræ have been slightly accentuated.

The chains of *external iliac glands* lie along the sides and the front of the vessels—the lateral chain in the groove between the artery and the psoas, the medial chain chiefly along the pelvic brim behind the vein. The most conspicuous members are two glands that lie one on each side of the artery immediately above the inguinal ligament. The medial gland receives most of the lymph from the free parts of the lower limb and some of the lymph from the true pelvis; the lateral gland receives the lymph from the districts supplied by the inferior epigastric and deep circumflex iliac vessels. The efferent vessels of these two glands pass to glands higher up in the external iliac chains.

The *common iliac glands* include a pair of lateral groups alongside the arteries and a median group which lies between the arteries and connects the two lateral groups. The lateral groups receive lymph from the lower limbs and the pelvis, transmitted to them through the external and internal iliac glands, while the median group receives lymph from the pelvic organs partly directly and partly through sacral and internal iliac glands. Their efferents carry the lymph to the aortic glands.

The *aortic glands* are large and numerous. Some of them lie on the front of the aorta, but most of them are along its sides. Those along its left side form a broad continuous chain; the inferior vena cava disperses those along the right side so that some of them lie between the vessels, some on the front of the vena cava, and some behind it, protruding to its lateral side.

These glands receive lymph-vessels directly (1) from the parts immediately adjacent to them, and (2) from the testis in the male, the ovary, uterus and uterine tube in the female. They receive indirectly through other glands (1) the lymph of the rest of the abdomen (except the small intestine, p. 305), and (2) the lymph of the pelvis and lower limbs. Their efferent vessels unite to form a pair of vessels called the *lumbar lymph-trunks*, which end in the cisterna chyli.

Cisterna Chyli (Fig. 194).—The cisterna chyli is the receptacle into which the lymph from the abdomen and lower limbs is poured. It is a narrow sac, about two inches long, and lies hidden behind the right crus of the diaphragm between the aorta and the vena azygos, in front of the upper two lumbar vertebræ and right lumbar arteries. It is

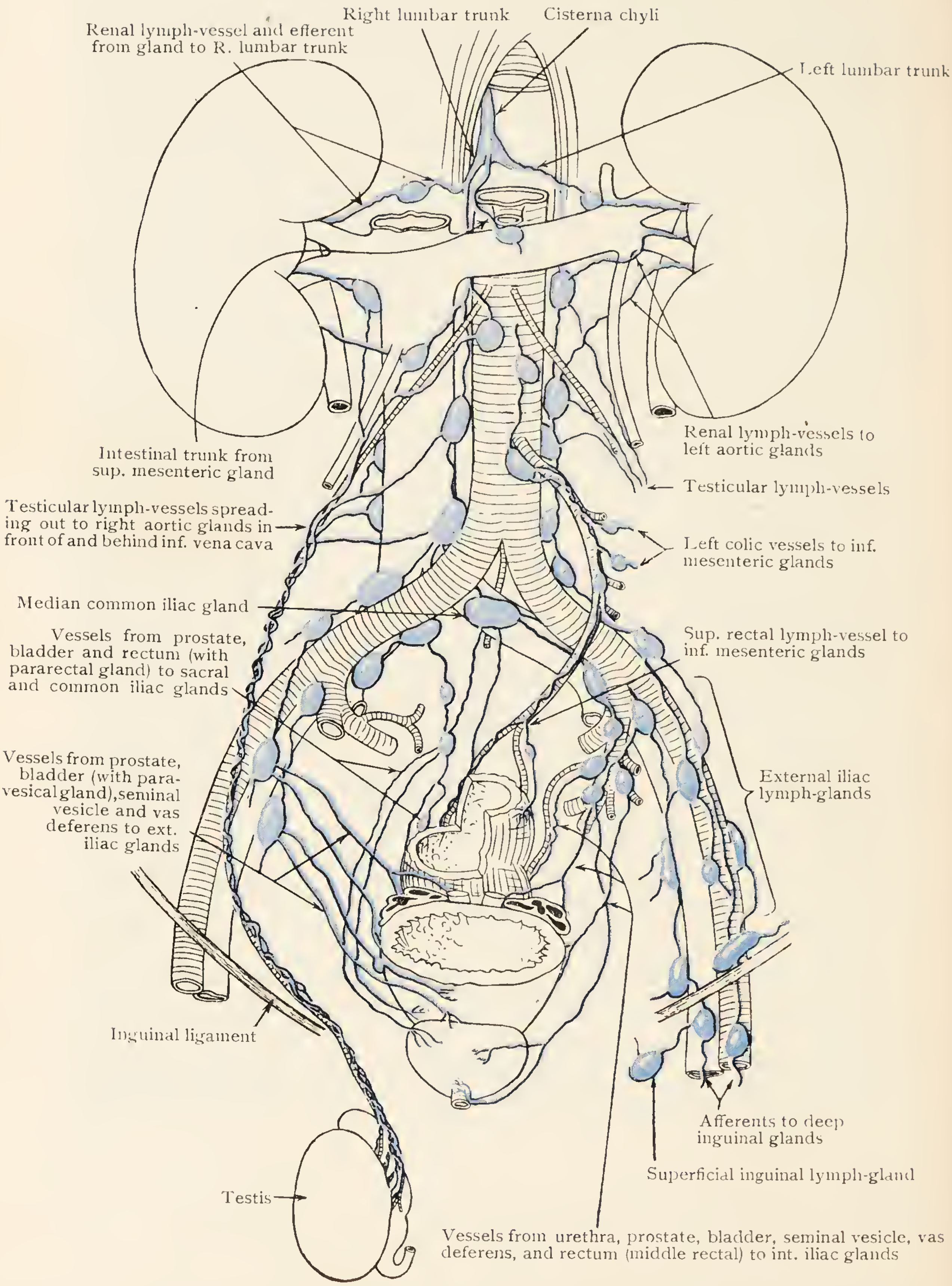

FIG. 194.—Diagram of Lymph-Vessels and Lymph-Glands of Male Pelvis and Abdomen. Cf. Fig. 219, p. 444 (female), in which other details common to the sexes will be found.

distinguished from the azygos vein by the whiteness of its walls. Its lower end receives a pair of *lumbar lymph-trunks*, which convey the lymph from the lower limbs and the greater part of the abdomen; about its middle, it receives the *intestinal lymph-trunk*, which brings the lymph from the small intestine. A pair of lymph-vessels from lower intercostal glands enters it near its upper end. At its upper end, it contracts to become the *thoracic duct*, which enters the thorax by passing through the aortic opening of the diaphragm.

Vena Azygos and Vena Hemiazygos Inferior.—The *azygos vein* usually springs from the back of the inferior vena cava at the level of the renal vein; it runs upwards and medially between the renal artery and the tendinous part of the right crus of the diaphragm, and, reaching the medial margin of the crus, it passes upwards under cover of its fleshy part and enters the thorax through the aortic opening of the diaphragm on the right side of the thoracic duct and the aorta. Occasionally, it is not found in the abdomen, for it may begin on the side of the twelfth thoracic vertebra by the union of the ascending lumbar vein and the subcostal vein.

The *inferior hemiazygos vein* is very slender in the abdominal part of its course. It arises from the back of the left renal vein, ascends between the renal artery and the left crus, and enters the thorax by piercing the fleshy part of the crus. Occasionally, it arises in the thorax from the union of the ascending lumbar and subcostal veins.

Fascia and Muscles on Posterior Wall of Abdomen

Three pairs of muscles lie in the posterior wall of the abdomen, viz.:—(1) the *psoas major*, an elongated fleshy mass which lies along the sides of the vertebral bodies and along the side of the inlet of the pelvis, and extends into the thigh; (2) the *quadratus lumborum*, a four-sided muscle that lies lateral to the psoas alongside the tips of the transverse processes, and extends from the iliac crest to the last rib; (3) the *iliacus*, a thick, fan-shaped muscle situated lateral to the psoas in the iliac fossa and in the thigh.

The fascia which covers the muscles must be studied first.

Fascia of Quadratus Lumborum.—When the fascia which covers the anterior surface of the quadratus lumborum is followed medially it will be found to be attached to the transverse processes of the lumbar vertebræ. Traced laterally it will be found to join the posterior aponeurosis of the transversus abdominis muscle. Inferiorly, it is attached to the iliac crest and to the ilio-lumbar ligament. Superiorly, it ascends behind the lateral arcuate ligament and the lower part of the diaphragm to be attached to the last rib. It is the anterior layer of the *lumbar fascia*, which the dissectors have examined already, and, with the middle layer, it encloses the quadratus in a fascial envelope. The lateral arcuate ligament fuses with it, and above the level of that ligament it is very thin.

Fascia of Psoas and Iliacus.—One continuous mem-

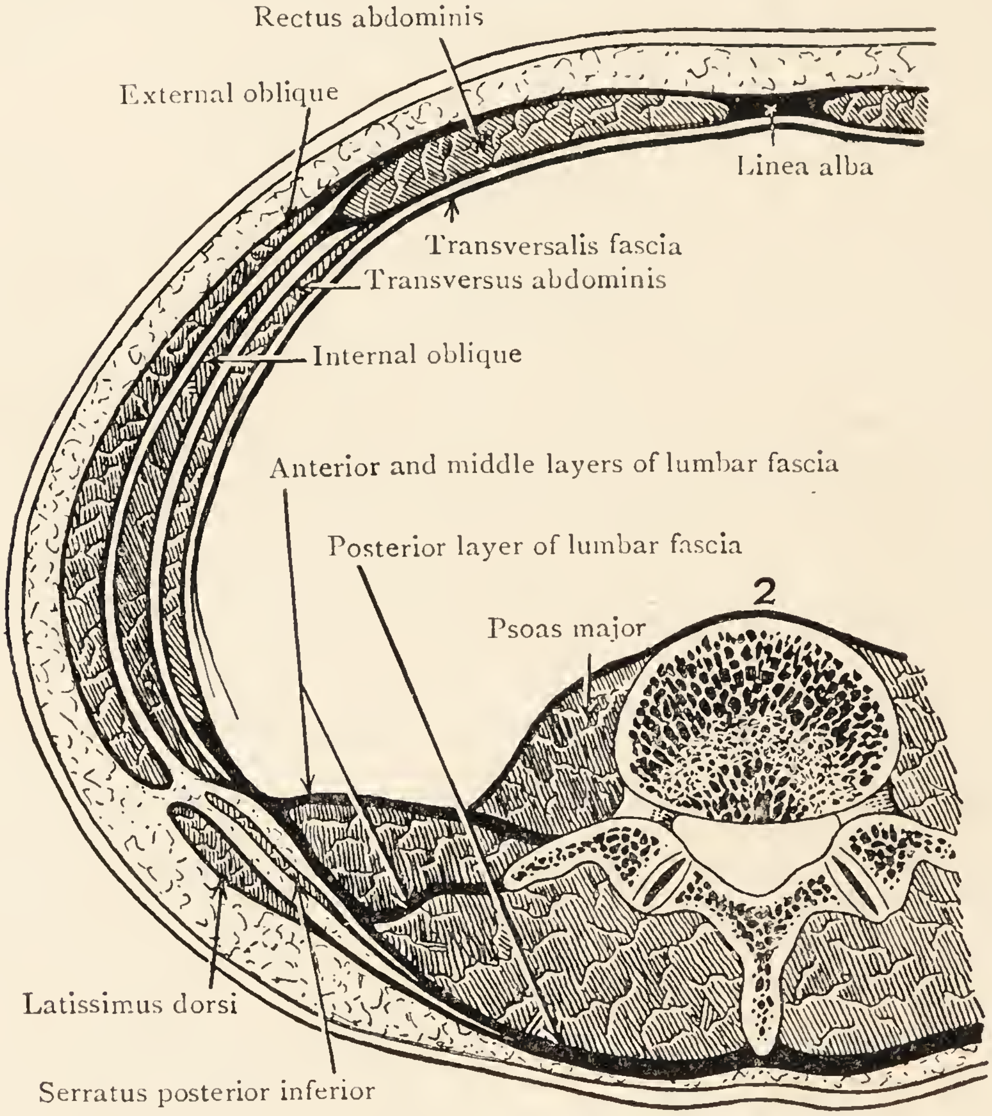

FIG. 195.—Diagram of Lumbar Fascia and Sheath of Rectus Abdominis.

branous sheet of fascia covers the anterior surfaces of the psoas and iliacus muscles. *Above* the iliac crest, where it is in relation only to the psoas, it is thin and narrow. Medially, it is fixed to the vertebral column by a series of fibrous arches which bridge over the lumbar arteries; laterally, it curves backwards over the psoas to blend with the fascia of the quadratus; superiorly, it is fused, with the medial arcuate ligament, and is then continued upwards into the thorax as a very thin layer over the uppermost part of the psoas.

Below the iliac crest the fascia expands so as to cover both the psoas and the iliacus, without sending a septum backwards between them ; at the same time it becomes much denser and thicker and is called the *fascia iliaca.* Laterally, this fascia is firmly fixed to the iliac crest ; medially, it sweeps over the psoas, and is attached to the brim of the true pelvis. Inferiorly, its medial part passes downwards into the thigh behind the large vessels to form the posterior wall of the sheath that surrounds the proximal inch and a half of the femoral vessels, while its lateral part blends with the fascia transversalis at the back of the inguinal ligament (Figs. 116, 117, pp. 239, 240).

The fascia iliaca is only loosely attached to the muscles : the fingers can easily be passed between them.

Surgical Anatomy.—The attachments of the ilio-psoas fascia are of high surgical importance. When a "psoas abscess" forms as the result of tubercular disease of the lumbar vertebræ, the pus readily passes downwards within the psoas sheath and may be conducted behind the inguinal ligament so as to point in the thigh. It cannot enter the true pelvis owing to the attachment of the fascia iliaca to the pelvic brim.

***Dissection.*—Clean the muscles of the posterior wall ; but preserve the medial part of the fascia iliaca until the pelvis is dissected ; and avoid injury to the vessels and nerves related to the muscles.**

Quadratus Lumborum.—The quadratus lumborum muscle *arises* from the ilio-lumbar ligament and from the adjoining part of the iliac crest. It receives two or three slips also from the lower lumbar transverse processes. As it passes upwards it narrows slightly, and it is *inserted* into the medial half of the last rib, and also by four tendinous slips into the upper four lumbar transverse processes.

To reach the last rib, it passes behind the diaphragm, and the front of its uppermost part is covered therefore with pleura. It is overlapped anteriorly by the psoas major, and posteriorly by the sacro-spinalis, which, indeed, entirely conceals its upper part—a point to be noted in an operation to expose the kidney from behind.

It is supplied by twigs from the anterior primary rami of the upper four lumbar nerves. It is a lateral flexor of the vertebral column ; and, acting with its fellow of the opposite side, it is a muscle of inspiration, for it helps to fix the lower ribs and so converts them into fixed points from which the diaphragm can act.

Psoas Major.—The psoas major muscle arises from the vertebral column by three distinct series of origins :—(1) by five thick fleshy slips from the transverse processes of the lumbar vertebræ ; (2) by five slips, each of which arises from an intervertebral disc and the contiguous margins of the bodies of two vertebræ—including the last thoracic and all the lumbar vertebræ ; (3) from the tendinous arches which bridge over the lumbar arteries and protect those vessels from the pressure of the contracting muscle.

Since the upper end of the muscle reaches the twelfth thoracic vertebra, its uppermost part is in the thorax behind the diaphragm.

The psoas major tapers slightly as it extends downwards along the brim of the true pelvis, and, after passing behind the inguinal ligament, it ends in a tendon which appears first on its lateral border and is inserted into the lesser trochanter of the femur. The tendon gives insertion to part of the iliacus.

It is supplied by twigs directly from the anterior primary rami of the second, third and fourth lumbar nerves, and indirectly through the femoral nerve.

Psoas Minor.—This muscle is found on the anterior surface of the psoas major in sixty per cent. of bodies. It has a short, slender fleshy belly which springs from the bodies of the last thoracic and first lumbar vertebræ and the disc between them, and it tapers into a long, slender, glistening tendon which spreads out inferiorly and partly blends with the fascia iliaca and is inserted partly into the pectineal line. It is supplied by a twig from the anterior primary ramus of the first lumbar nerve.

Iliacus.—The iliacus muscle arises chiefly from the floor of the iliac fossa. It is inserted partly into the tendon of the psoas major, partly into the lesser trochanter and partly into the surface immediately below the trochanter. The arteries seen ramifying on its surface are iliac branches of the ilio-lumbar artery, which arises from the internal iliac and ascends out of the true pelvis into the abdomen proper.

It is supplied, in the abdomen, by a branch of the femoral nerve.

Actions of Psoas and Iliacus.—Together with the psoas major, the iliacus acts as a flexor and medial rotator of the femur until the hip joint is flexed, and then the two muscles rotate the femur laterally. Acting from below, the two muscles bend the trunk forwards at the hip joint ; and the psoas major can also bend the vertebral column forwards and sidewards, in which action it is aided by the psoas minor.

Nerves on Posterior Wall of Abdomen

The nerves included under this heading are, on each side :—the *sympathetic trunk* and its branches, the *subcostal nerve*, and the anterior primary rami of the *lumbar nerves* and their branches. These should now be dissected.

Dissection.—The greater part of the left sympathetic trunk has been exposed already. Push the inferior vena cava aside, and expose the right trunk. Without injuring their branches, trace each trunk upwards till it disappears behind the medial arcuate ligament, and downwards into the fat behind the common iliac vessels. Clear away the fat, clean the nerves and vessels found there, and trace the trunk into the pelvis. Next, identify the branches which the trunk gives to the hypogastric plexus. Then, carefully detach the psoas from the discs and vertebral bodies, and, on the side of each vertebral body, trace branches backwards from the sympathetic trunk to a lumbar nerve ; at the same time, clean the lumbar vessels.

Sympathetic Trunk.—On each side, the sympathetic trunk enters the abdomen behind the medial arcuate ligament, and extends downwards in the groove between the backbone and the anterior border of the psoas major muscle. *Superiorly*, it is continuous with the thoracic portion of the trunk, and *inferiorly*, it passes behind the common iliac vessels and enters the true pelvis. On the right side it is covered by the inferior vena cava ; and on both sides the lumbar vessels pass behind it.

The *lumbar ganglia* vary in number and are placed very irregularly on the sympathetic trunk in the abdomen. One may be found opposite the body of each lumbar vertebra ; but, as a rule, there are only four on each side.

Branches.—Rami communicantes and branches of distribution proceed from each gangliated trunk.

The *rami communicantes* are slender cords that connect the ganglia with the anterior primary rami of the lumbar nerves. One or more will be found accompanying each lumbar artery on the side of the vertebral body under cover of the psoas major.

The rami communicantes are of two kinds—white and grey. The *white rami communicantes* are composed of medullated fibres which pass from the anterior primary rami of spinal nerves to the sympathetic trunk. In the lumbar region there are only two white rami, and they proceed from the upper two lumbar nerves. The *grey rami communicantes* are much more numerous, and are formed of non-medullated fibres which stream out in an irregular manner from the sympathetic trunk to the anterior primary rami of all the lumbar nerves.

The *branches of distribution* are small filaments which arise irregularly from the lumbar part of the trunk and pass downwards and medially to the aortic and hypogastric plexuses.

Subcostal Nerve.—This nerve is the anterior primary ramus of the last thoracic nerve. It usually sends a branch downwards through the upper part of the psoas to join the first lumbar nerve ; and it then passes out of the thorax into the abdomen behind the lateral arcuate ligament. In the abdomen it runs across the quadratus lumborum in front of the lumbar fascia behind the kidney, near the last rib but below the subcostal vessels. Beyond the lateral border of the quadratus, near the tip of the last rib, it pierces the transversus abdominis and runs downwards and forwards between that muscle and the obliquus internus ; in that part of its course, it was examined when the anterior wall was dissected.

> ***Dissection.***—To bring the anterior primary rami of the lumbar nerves into view, displace the psoas major muscle. First, find the *genito-femoral nerve* on the surface of the psoas and trace the nerve through the muscle to the lumbar nerves. Next, carefully complete the detachment of the psoas from its origin, disentangling the lumbar nerves from its substance ; then, clean the lumbar nerves and trace their branches.

Lumbar Nerves.—The anterior primary rami of the five lumbar nerves emerge from the intervertebral foramina below the corresponding vertebræ, and pass into the posterior part of the substance of the psoas major. They increase in size from above downwards, and each nerve is connected with the sympathetic trunk by one or more rami communicantes. Twigs are given by the upper four to the intertransverse muscles and to the quadratus lumborum, by the first to the psoas minor, and by the second, third and fourth to the psoas major.

The upper four then divide to join one another and to form the roots of the six named nerves that spring from them. The upper three and the upper part of the fourth thus form the *lumbar plexus*. The lower branch of the fourth descends to the fifth and unites with it to form a thick cord called the *lumbo-sacral trunk*, which passes into the true pelvis to take part in forming the sacral plexus. Since the fourth nerve forks in this way to take a share in both the lumbar plexus and the sacral plexus, it is sometimes called the *nervus furcalis*.

Lumbar Plexus.—The lumbar plexus is formed therefore from the anterior primary rami of the upper three lumbar nerves and part of the fourth; and the subcostal nerve frequently takes part by the branch which it sends to the first lumbar. The plexus lies in the substance of the psoas major muscle on the front of the lower four lumbar transverse

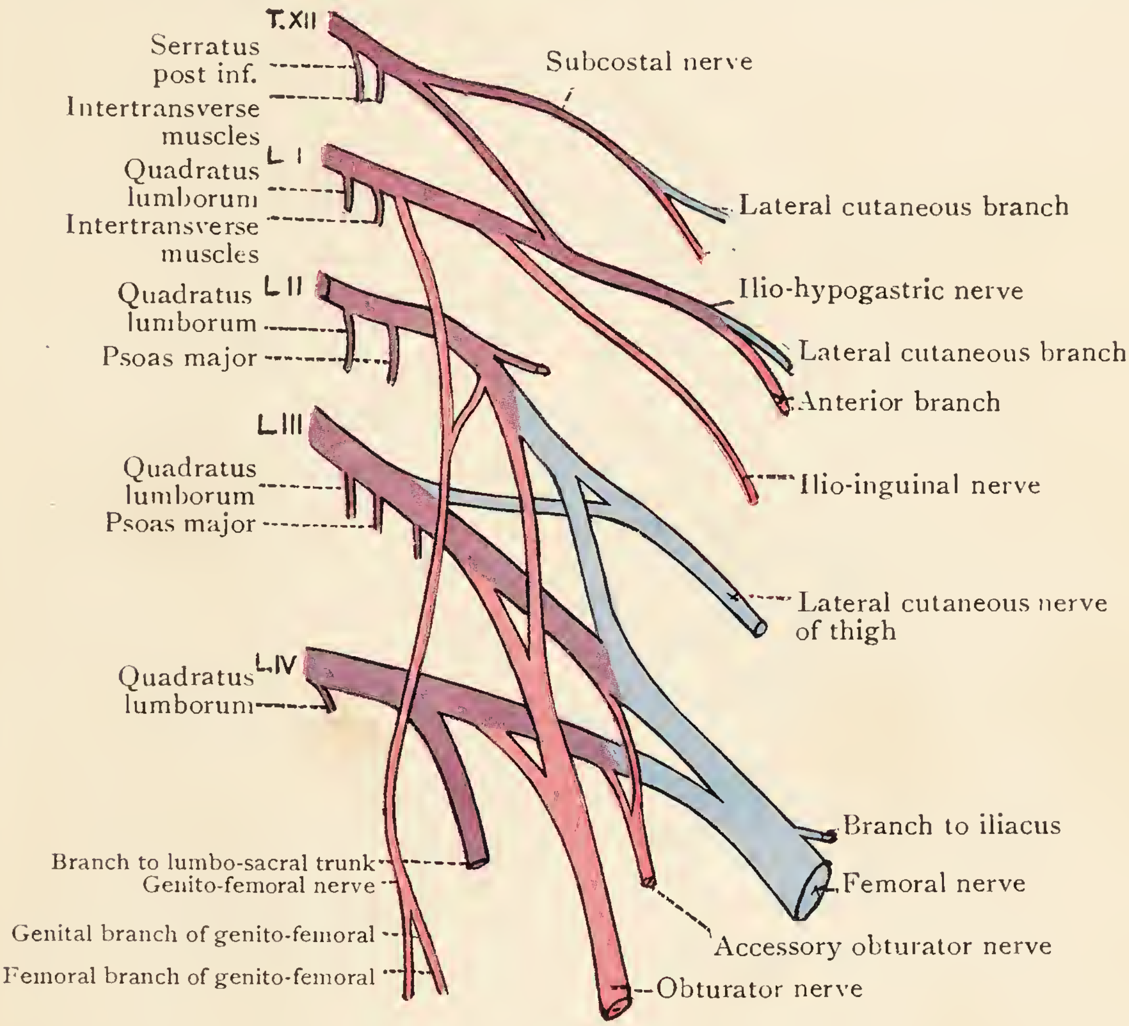

FIG. 196.—Diagram of Lumbar Plexus.

processes, and is thickest and most plexiform on the front of the fifth.

The following six named nerves spring from the plexus:—

1.	Ilio-hypogastric,	derived from	1st lumbar nerve.
2.	Ilio-inguinal,		
3.	Genito-femoral,	,,	1st and 2nd lumbar nerves.
4.	Lateral cutaneous n. of thigh,	,,	2nd and 3rd lumbar nerves.
5.	Obturator,	,,	2nd, 3rd and 4th lumbar nerves.
6.	Femoral,	,,	2nd, 3rd and 4th lumbar nerves.

These nerves all arise in the substance of the psoas major. The genito-femoral emerges through the anterior surface of the muscle; the obturator emerges through its medial margin at the back part of the pelvic brim ; the other four emerge through the lateral margin.

The manner in which the nerves spring from the plexus may now be studied. The *first* lumbar primary ramus breaks up into three branches, viz., the ilio-hypogastric, the ilio-inguinal, and the upper root of the genito-femoral. The *second*, *third* and *fourth* each split into a ventral and a dorsal division. The three ventral divisions unite to form the obturator nerve ; the three dorsal divisions are larger than the

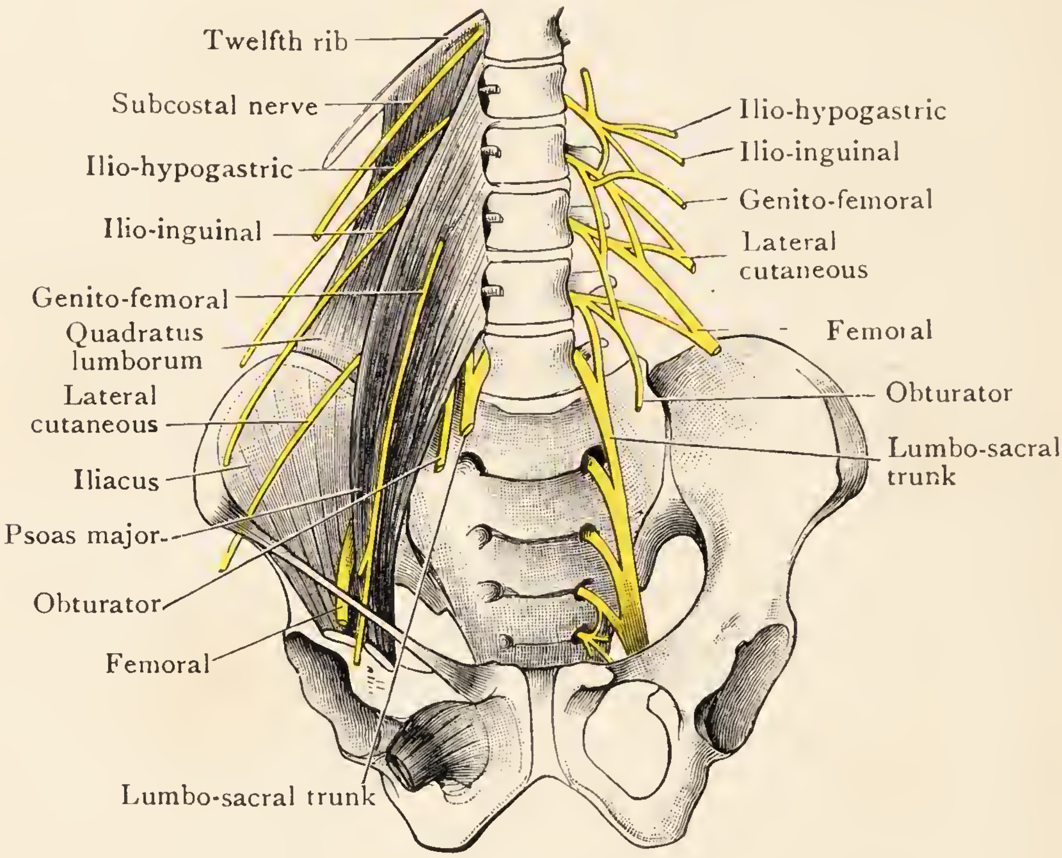

FIG. 197.—Lumbar Plexus *in situ* (semi-diagrammatic).

ventral, and unite to form the femoral nerve. But other branches come off from certain of the divisions. Thus, the lower root of the genito-femoral springs from the ventral division of the second nerve, whilst the two roots of the lateral cutaneous nerve of the thigh take origin from the dorsal divisions of the second and third.

The **ilio-hypogastric nerve** emerges from the lateral border of the psoas about two inches below the last rib and runs laterally and downwards across the quadratus lumborum behind the kidney ; at the lateral margin of the quadratus, a little above the iliac crest, it pierces the transversus abdominis. Its further course has already been studied (p. 197).

The **ilio-inguinal nerve** runs the same course as the ilio-hypogastric, but at a slightly lower level ; and it also has been examined in the anterior wall of the abdomen.

The **genito-femoral nerve** is very slender. It passes forwards through the psoas and emerges on its anterior surface near its medial margin at the level of the third lumbar vertebra. It descends over the front of the psoas, and, at a variable point, it divides into a femoral and a genital branch.

The *femoral branch* runs downwards along the lateral side of the external iliac artery, where it crosses in front of the deep circumflex iliac vessels and then passes behind the inguinal ligament into the thigh. The *genital branch* pierces the fascia on the psoas, passes on to the front of the external iliac artery, and *in the male* it accompanies the testicular artery through the deep inguinal ring into the inguinal canal, where it supplies the cremaster muscle; *in the female* it passes unaccompanied into the inguinal canal, where it supplies the round ligament of the uterus and sends a filament along the ligament to the skin of the labium majus.

The **lateral cutaneous nerve of the thigh** emerges from the lateral border of the psoas major at the iliac crest and descends obliquely across the iliacus muscle, behind the fascia iliaca and behind the ascending colon or the descending colon, to reach the anterior superior spine of the ilium. At the medial side of that spine, it leaves the abdomen by passing behind the lateral end of the inguinal ligament to enter the thigh.

The **femoral nerve** is the thickest branch of the plexus. It emerges through the lateral border of the psoas immediately below the iliac crest, runs downwards in the groove between the psoas major and iliacus, behind the cæcum or behind the descending colon, and passes behind the inguinal ligament into the thigh. In the abdomen, it gives branches to the psoas major and the iliacus.

The **obturator nerve** emerges from the medial border of the psoas major where that muscle reaches the brim of the pelvis. It pierces the fascia and passes into the pelvis, where it will be examined later.

A small nerve, called the *accessory obturator*, is occasionally found. It may spring either from the obturator or from the third and fourth lumbar nerves. It proceeds downwards along the medial side of the psoas major and enters the thigh by passing over the pubic bone under cover of the pectineus. In the thigh, it gives branches to the hip joint and unites with the obturator nerve. It sometimes supplies a twig to the pectineus muscle.

Lumbo-Sacral Trunk.—The lumbo-sacral trunk is formed by the union of the anterior primary ramus of the fifth lumbar nerve with the descending branch of the fourth. The *descending branch of the fourth nerve* is very variable in thickness. It descends in the substance of the psoas, across the front of the fifth lumbar transverse process, to reach the fifth nerve.

To reach the pelvis, the lumbo-sacral trunk runs downwards and laterally over the ala of the sacrum so closely applied to the bone that it produces a slight groove. It is hidden by the fat behind the common iliac vessels and by the psoas, which overlaps it ; the ilio-lumbar artery and the obturator nerve are on its lateral side (also overlapped by the psoas) ; the sympathetic trunk, at first on a more superficial plane, is medial to it as they enter the pelvis.

The descending branch of the fourth nerve crosses the medial part of the fifth lumbar transverse process, and the roots of the obturator and femoral nerves cross the lateral part ; several nerves may therefore be implicated in deformity, disease or injury of this process, and the dissectors should examine this region carefully.

Subcostal and Lumbar Vessels and Intervertebral Joints

The study of these vessels and joints is the last stage in the examination of the abdomen proper.

Subcostal Vessels.—The **subcostal artery** is the last parietal branch of the thoracic aorta. It appears in the abdomen by passing behind the lateral arcuate ligament above the subcostal nerve. It accompanies the nerve across the quadratus lumborum and through the transversus ; and it ends in twigs to the transversus and internal oblique.

The *subcostal vein* lies above the artery, close to the last rib ; and the order, from above downwards, is therefore—vein, artery, nerve. It passes medially behind the lateral arcuate ligament and joins the azygos vein or the inferior hemi-azygos vein in the thorax.

Lumbar Vessels.—Four pairs of **lumbar arteries** spring from the back of the aorta, and a fifth pair from the median sacral artery.

The four that spring from the aorta pass laterally over the bodies of the upper four lumbar vertebræ behind the sympathetic trunk, and then disappear under cover of the psoas major. On each side, the upper two pass behind the crus of the diaphragm also ; and, on the right side, the upper two pass behind the cisterna chyli and the azygos vein, while the lower two pass behind the inferior vena cava.

Having reached the psoas, each lumbar artery curves backwards over the side of the vertebral body to reach the root of the transverse process in company with one or more rami communicantes. As they curve backwards, the vessels and nerves are under cover of the psoas and are protected from its contractions by a fibrous sheet which bridges over the concavity of the side of the vertebral body. At the root of the transverse process, the artery gives off a posterior branch, and then runs laterally, below the transverse process, behind the psoas, and onwards behind the quadratus lumborum to reach the interval between the transversus and internal oblique, where it ends in small branches. The fourth artery often passes in front of the quadratus.

The *posterior branch* runs backwards between transverse processes, and ends in the muscles and skin of the loin; on its way it sends a *spinal branch* into the vertebral canal to supply the fat and the spinal membranes.

The fifth pair are small. They spring from the median sacral artery behind the left common iliac vein, and each curves backwards to end by anastomosing with branches of the ilio-lumbar artery.

The upper four pairs of **lumbar veins** accompany their arteries, lying above them and skirting the lower edges of the transverse processes; but they vary in their mode of termination. The third and fourth pairs end in the inferior vena cava—those of the left side having to cross behind the aorta to reach the vena cava. The upper two pairs run medially with their arteries no farther than the roots of the transverse processes; they end there in the ascending lumbar vein. Occasionally, the upper two of the right side accompany their arteries farther and end in the azygos vein.

The fifth lumbar vein is very short, and it ends in the ilio-lumbar vein.

The *ascending lumbar vein* is a long anastomotic channel that links together:—(1) veins of the pelvis called lateral sacral veins; (2) the ilio-lumbar vein; (3) the upper four lumbar veins; and (4) the subcostal vein.

In the abdomen, it lies in the substance of the psoas major, on the front of the roots of the lumbar transverse processes.

> ***Dissection.***—**The lower limbs having, by this time, been removed from the trunk, the pelvis also may be detached. Place a ligature around the end of the aorta and one around the inferior vena cava at the same level, and divide the vessels immediately above the ligatures. Next, carry the knife through the intervertebral disc between the third and fourth lumbar vertebræ. Then, turn the body first on one side and then on the other, and divide all the soft parts at that level, passing the knife deeply between the two vertebræ from the sides and from behind till the articular processes are reached. Finally, draw the two parts of the trunk as far apart as possible, and disarticulate the vertebræ at the joints between the articular process. In the bodies of old people, the saw may be required.**

Intervertebral Joints.—Examine the parts of the vertebræ exposed and study the joints between them (p. 133). The **bodies** are united by an *intervertebral disc* and *anterior* and *posterior longitudinal ligaments*; the **articular processes** by *capsular ligaments* lined with synovial membrane; the **transverse processes** by thin *intertransverse ligaments*; the **laminæ** by a pair of *ligamenta flava*; and the **spines** by *interspinous* and *supraspinous ligaments*.

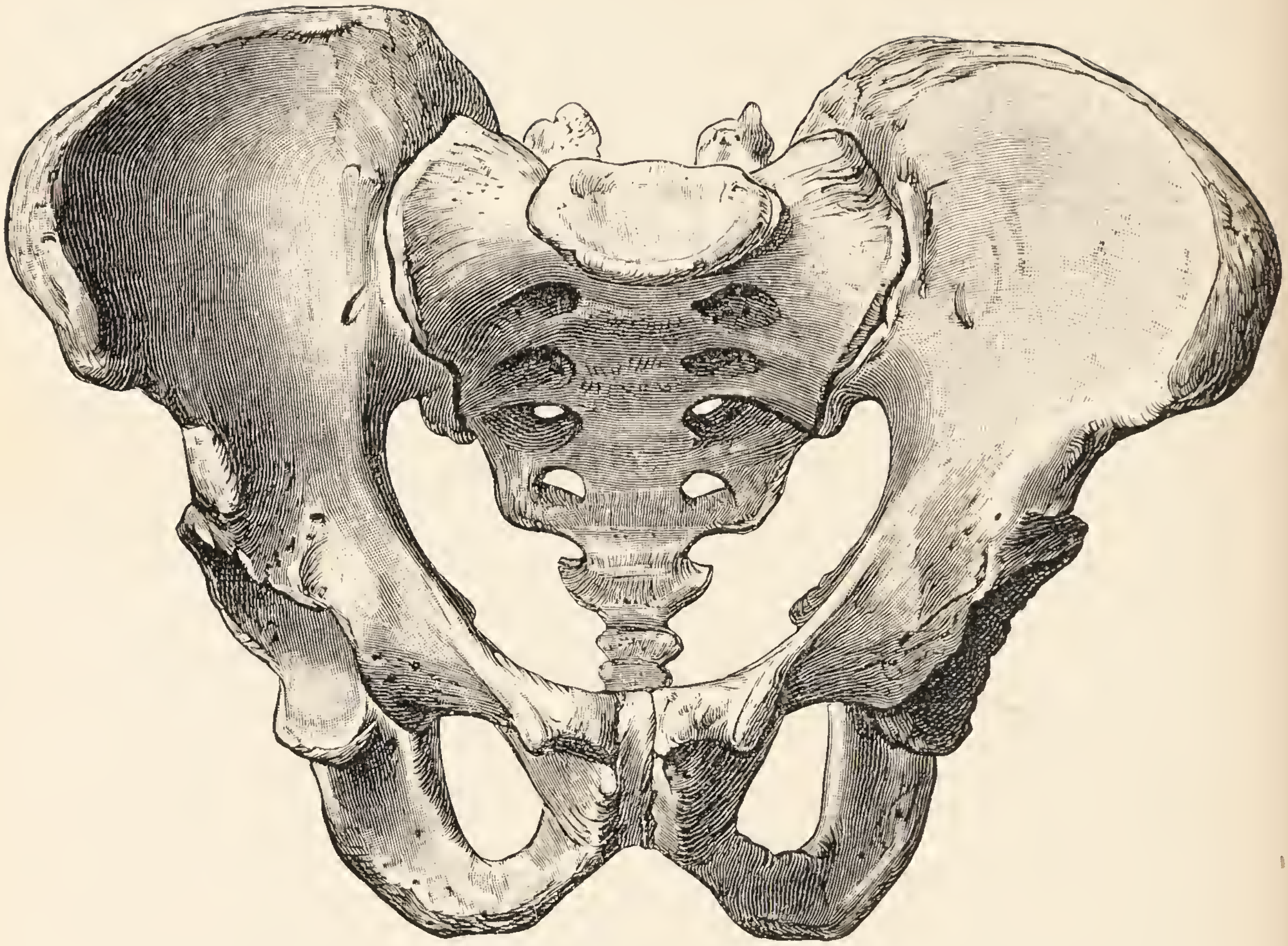

FIG. 198.—Male Pelvis seen from the front. Compare with Fig. 200.

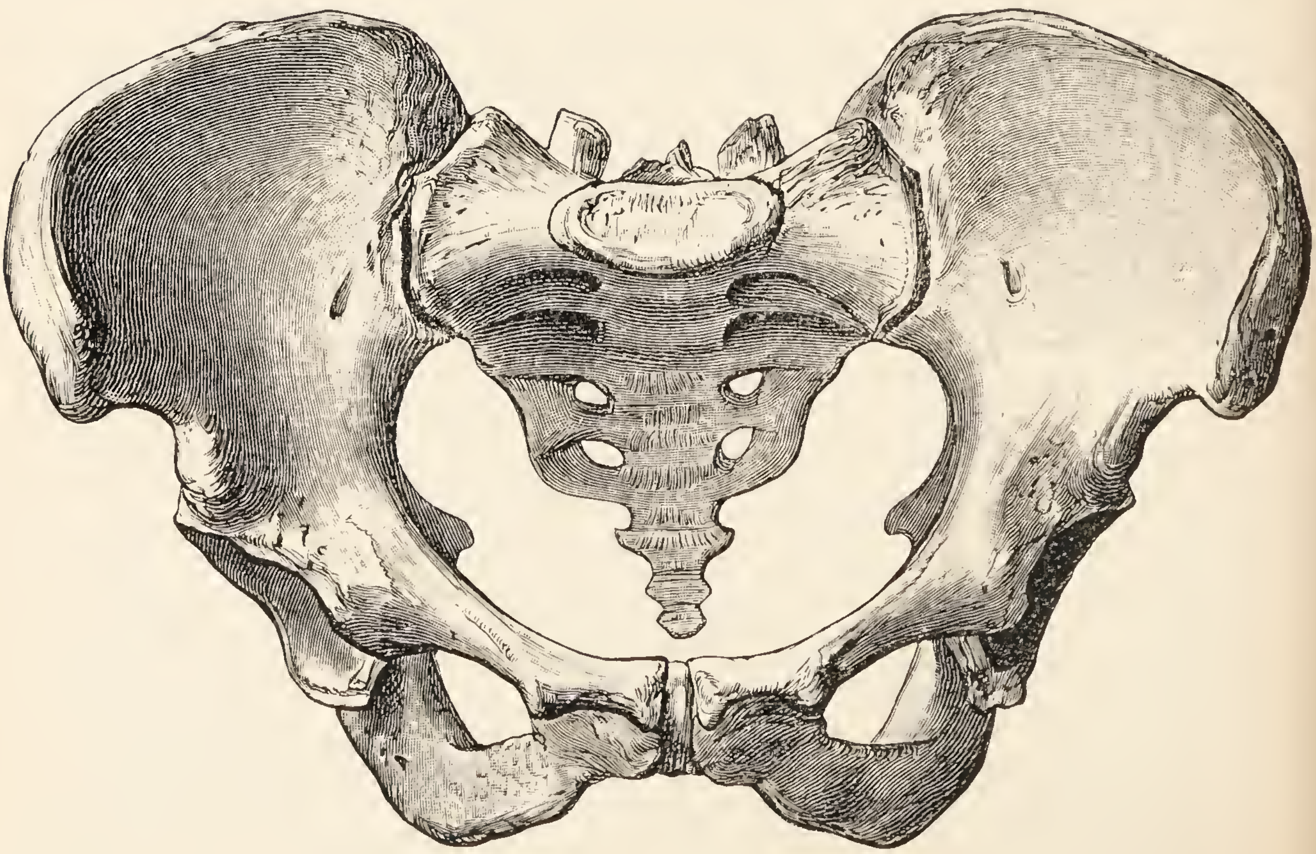

FIG. 199.—Female Pelvis seen from the front. Compare with Fig. 201.

PELVIS

INTRODUCTION

Except where otherwise indicated, the description and dissection directions apply to both male and female pelvis.

The dissectors should note in the first place that the Pelvis, when set on the table for the examination of its contents, does not occupy the same planes as it would do if it were in an upright body or even in a recumbent body. When the body is erect, the pubic tubercles and the anterior superior iliac spines are in the same vertical plane. Place the skeleton of a pelvis against the wall with those points touching the wall, and thus obtain an accurate idea of the proper inclination of the pelvis ; and then note certain features of the pelvis as a whole before proceeding to examine its contents (Figs. 198-201).

The pelvis takes so large a share in bounding the abdomen that it is convenient to divide it into two parts called the *false pelvis* and the *true pelvis*. The division is effected by an imaginary plane called the *plane of the pelvic brim*. The plane lies across the pelvis, touching the sacral promontory and the pubic symphysis. The part above and in front of the plane is the *false pelvis* ; it forms part of the boundary of the abdomen proper, and its contents have therefore been studied already. The part below and behind the plane is the *true pelvis*, which will now engage the dissectors' attention. It is the small, basin-like, lower part of the abdomen ; it is below and behind the lower part of the abdomen proper, with which it communicates by the wide, rounded aperture known as the *inlet of the pelvis*. Though the single term " pelvis " should be applied only to the whole pelvis, yet it is often used in the sense of true pelvis alone—the context making clear what is meant.

Walls of True Pelvis.—The walls include a supporting framework of bones, joints, ligaments and membranes. A great part of the framework is lined on the inside with muscles, and the muscles are covered with fascia. In the pelvic walls there are therefore three strata from without inwards—osteo-fibrous, muscular, fascial.

The *bones* of the framework are the sacrum and coccyx behind and the lower half of the hip-bone at the side and in front. The *joints* are the sacro-coccygeal joint, a pair of sacro-iliac joints and the pubic symphysis. The *ligaments* are the ligaments of those joints and also the sacro-tuberous and sacro-spinous ligaments. On each side, these two ligaments bridge the gap that separates the hip-bone from the sacrum and coccyx and convert it into the greater and lesser sciatic foramina.

The *membranes* are :—(1) the perineal membrane, which fills up the greater part of the pubic archway ; (2) the obturator membrane on each side—a felted membrane which almost completely closes the obturator foramen, being attached all round its margins except antero-superiorly, where it leaves a gap, called the *obturator canal*, by which the obturator nerve and vessels escape from the pelvis.

On the skeleton, examine now the boundaries of the inlet and outlet of the pelvis, and then the position of the muscles.

The boundaries of the *inlet* form the *pelvic brim*. From behind forwards, they are the sacral promontory, the arcuate line, the pubic crest and the pubic symphysis. When the soft parts are in place, the psoas major overlaps the inlet on each side, and reduces its width. The boundaries of the *outlet* have been examined already, for they are also the boundaries of the perineum—the coccyx, the sacro-tuberous ligaments, the ischial tuberosities, the sides of the pubic arch, and the pubic symphysis.

The *muscles* that form a partial lining of the pelvic framework are the piriformis, the coccygeus, the obturator internus, the deep transversus perinei and the sphincter urethræ. The piriformis lies on the sacrum in the dorsal wall ; the coccygeus, also in the dorsal wall, lies on the sacro-spinous ligament ; the obturator internus lies in the side wall ; the sphincter and deep transversus lie in the lower or ventral wall, on the perineal membrane.

The *fascia* is strong and dense where it covers the obturator internus and is specially named the *obturator fascia*. Over the piriformis and coccygeus it is a thin but definite layer, but over the sphincter and the deep transversus it is

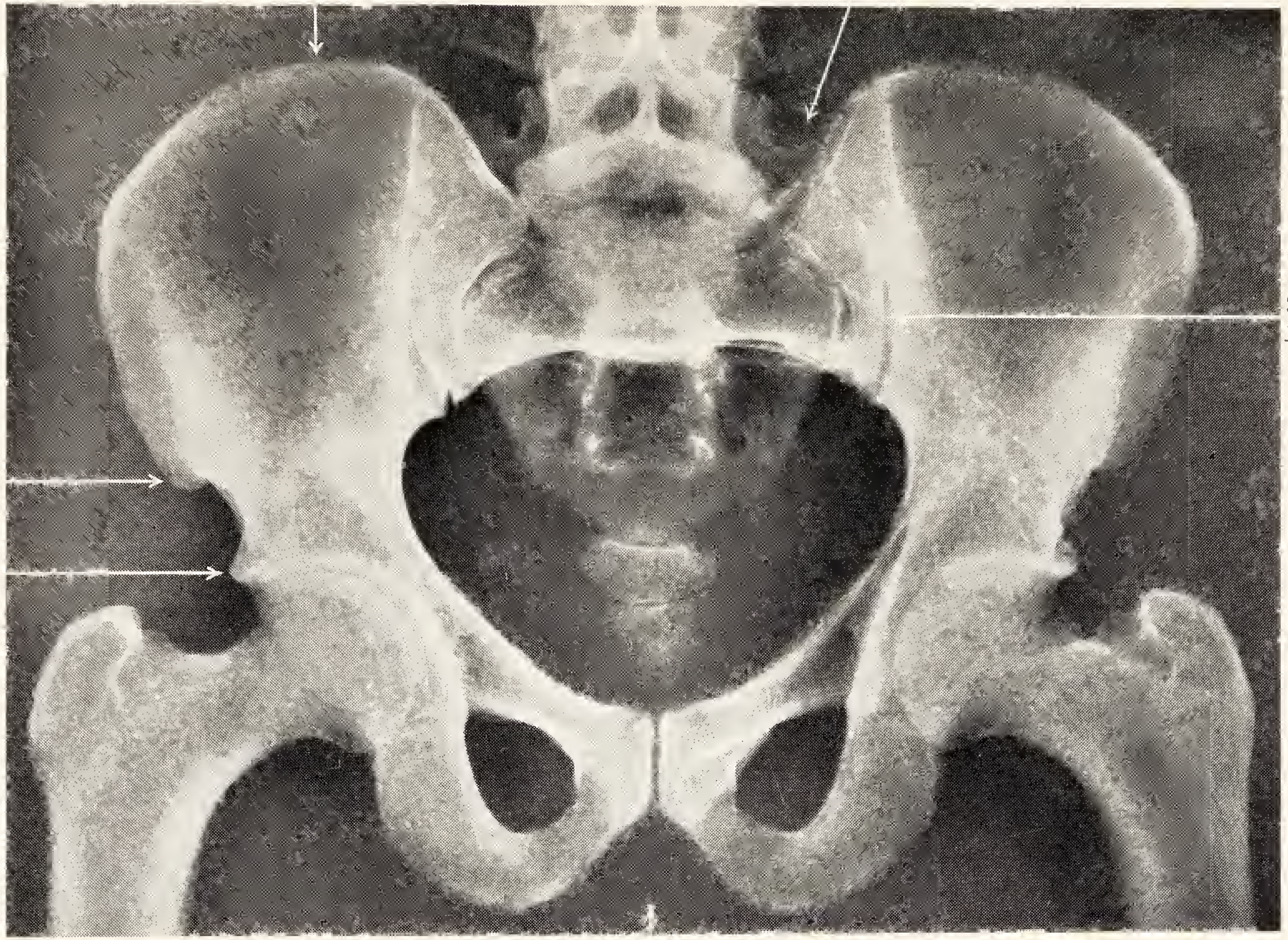

FIG. 200.—Radiograph of Dried Male Pelvis (man aged 22).

Compare with Fig. 201, noting the differences in proportions of the pelvis as a whole, and in the form of the pubic arch and of the inlet of the true pelvis.

[Facing p. 400

PLATE XXIV

FIG. 201.—Radiograph of Living Female Pelvis (girl aged 17). (Dr. J. Duncan White)

Compare with Fig. 200, noting the differences in proportions of the pelvis as a whole, and in the form

[Facing p. 40

usually loose and ill-defined. Where the muscles fail to meet each other, the fascia is continuous with the periosteum at their margins.

Floor of Pelvis.—The cavity of the true pelvis is divided into upper and lower parts by a pair of muscles—the *levatores ani.* The lower part includes the ischio-rectal fossa of each

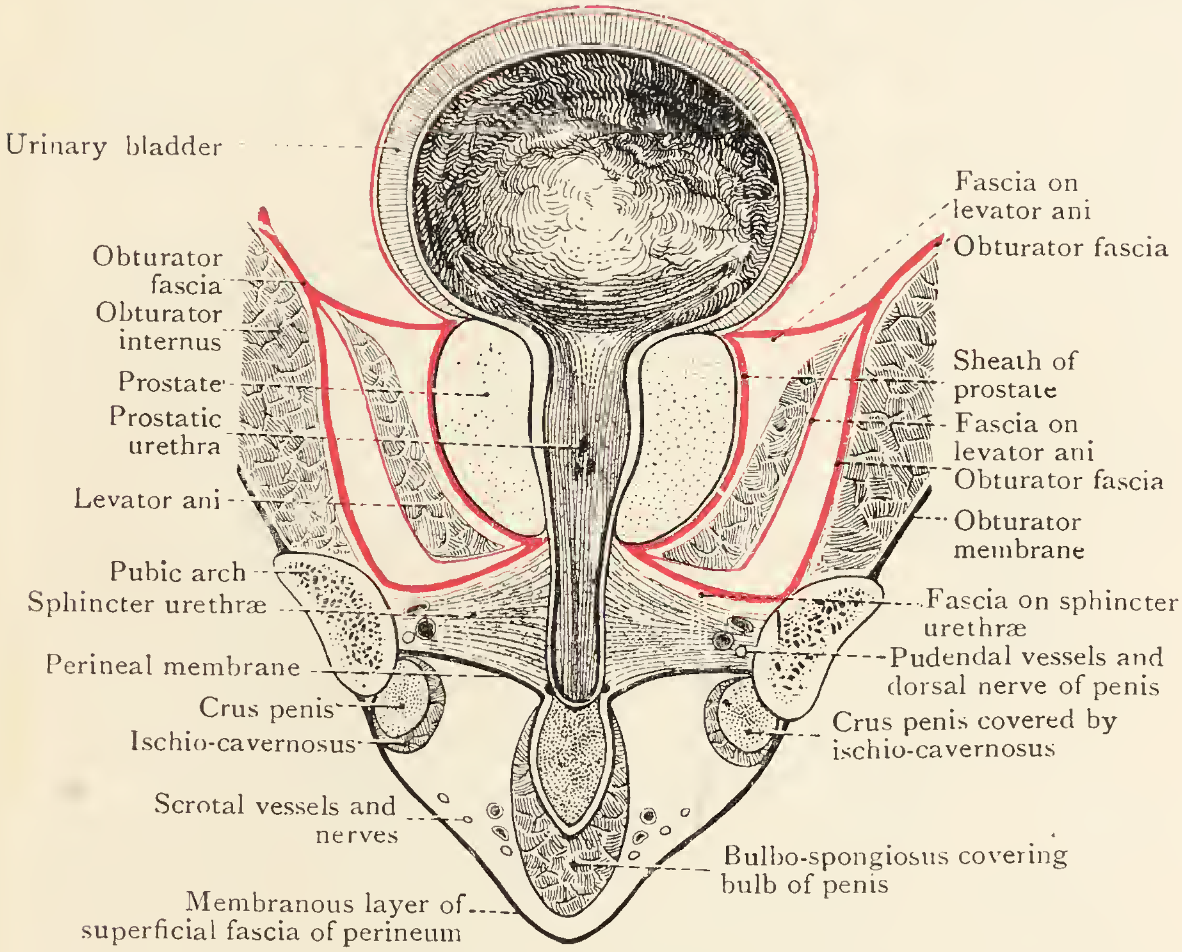

FIG. 202.—Coronal Section through the Bladder, Prostate, and Pubic Arch to show the arrangement of the Fascia of the Pelvic Muscles and Viscera in the Male (schematic). The fascia is depicted in red.

side, which has been dissected already. We limit the term "cavity of the true pelvis" to the upper part; the levatores ani therefore form the floor of the true pelvis; and they have a covering of fascia on their pelvic surface as well as on their perineal surface (Fig. 84, p. 154).

Contents of True Pelvis.—The names of the structures in the pelvis are given later, but certain points regarding their general arrangement are more conveniently mentioned now.

Note first, with regard to the *nerves*, that the sympathetic trunks and the spinal nerves (except the obturator) are outside the fascia; they are therefore in the pelvic wall rather than in the cavity, and the visceral branches of the spinal nerves pierce the fascia to reach the viscera. The *viscera* are embedded in extraperitoneal fatty tissue, and have only a partial covering of *peritoneum*, or none at all. The *extra-peritoneal tissue* is very abundant ; it is connected loosely with the fascia on the muscles ; and, around the viscera, it is to some extent condensed to form loose fascial sheaths for them. The *blood-vessels*, accompanied by the sympathetic plexuses, lie in the loose, fatty part of the extraperitoneal tissue ; their parietal branches pierce the muscular fascia to escape from the pelvis, and their visceral branches pierce the visceral fascial sheaths to reach the viscera.

It should be noted also that certain organs which lie in the pelvis are not counted among the pelvic viscera, because the dissector can lift them out of the pelvis without cutting the pelvic peritoneum ; these organs are the upper part of the pelvic colon, the lower coils of the ileum and, sometimes, the cæcum and vermiform appendix.

The following are the contents of the pelvis :—

Viscera

Both Sexes
- Pelvic colon.
- Rectum.
- Urinary bladder.

Male
- Prostate.
- Prostatic part of urethra.
- Vasa deferentia.
- Seminal vesicles.

Female
- The whole urethra.
- Uterus.
- Round ligaments of uterus.
- Uterine tubes.
- Ovaries and ovarian ligaments.
- Vagina.
- Ep-oöphoron and appendices vesiculosæ.

Blood-Vessels

- Internal iliac vessels and their branches and tributaries.
- Median sacral vessels.
- Superior rectal vessels.
- Venous plexuses of viscera.
- Ovarian vessels (*in female*).

Nerves

- Sympathetic trunks and their branches.
- Sympathetic plexuses and their offshoots.
- Obturator nerves.
- Sacral and coccygeal plexuses and their branches.

Extraperitoneal Tissue
Peritoneum

Before proceeding to study the contents of the pelvis, devote some attention to certain parts of its dorsal wall.

Dissection.—If the dissectors of the Head and Neck have laid open the *vertebral canal*, examine the nerves that have been left in the *sacral canal*. If the posterior wall of the vertebral canal is intact, remove it by saw-cuts along the medial sides of the posterior sacral foramina ; then, clear the *fat* and *veins* out of the sacral canal, lay open the tubes of *dura mater* and *arachnoid mater*, and trace the *nerve-roots* to their union with each other.

In either case, identify the *sacral* and *coccygeal cornua*, and clean the ligaments that connect them ; then, trace the structures that emerge through the lower end of the sacral canal. These structures are a thread-like fibrous band called the *filum terminale* in the median plane, and the *coccygeal* and *fifth sacral nerves* on each side. Follow the filum on to the back of the coccyx, and the nerves till they pierce the ligaments at the side of the coccyx.

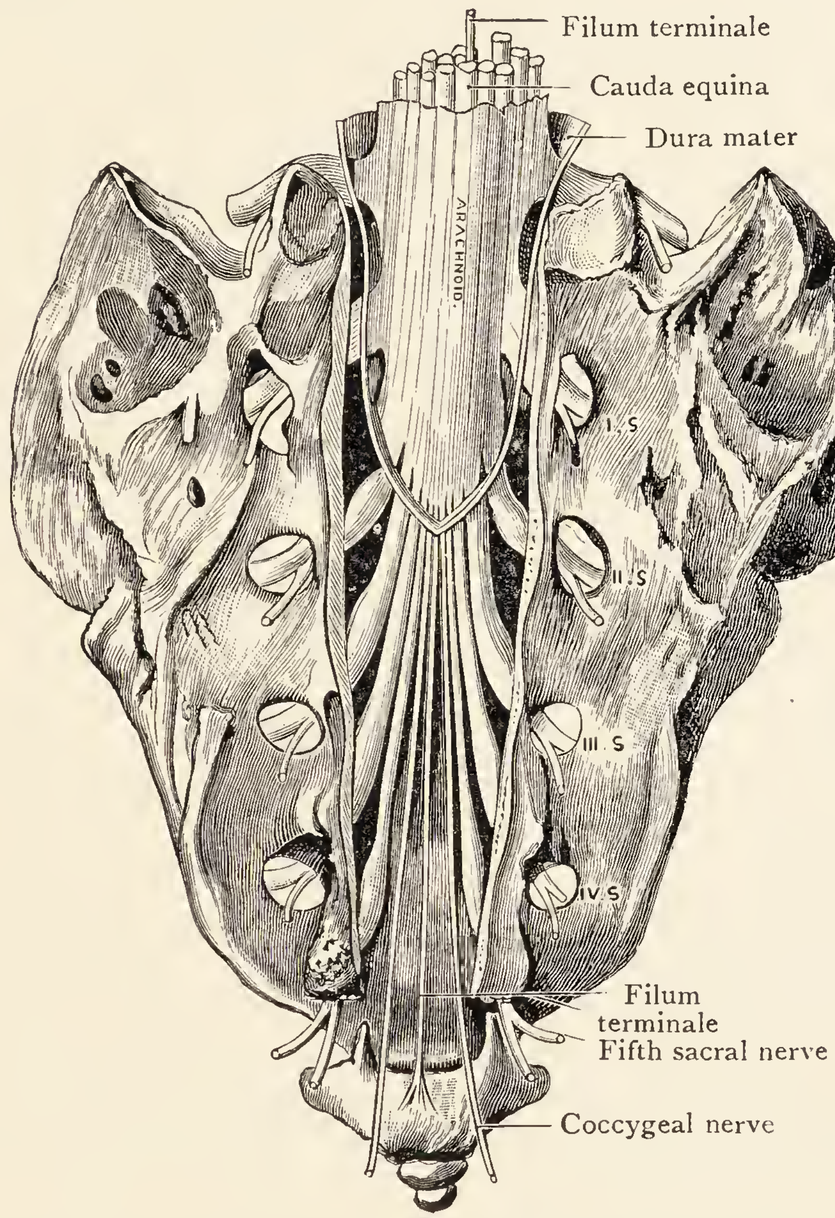

FIG. 203.—Sacral Nerve-Roots and the Membranes in relation to them (after Testut). The posterior wall of the Sacral Canal has been removed.

Contents of Sacral Canal.—The sacral canal is occupied by :—(1) the lowest parts of the tubes of the dura and arachnoid mater, (2) the filum terminale, (3) the roots of the sacral and coccygeal nerves, and (4) a quantity of soft fat in which small arteries and thin-walled veins ramify and anastomose.

Although the spinal cord does not extend farther down than the upper part of the second lumbar vertebra, the tubes of *dura mater* and *arachnoid mater* are continued downward around the bundle of nerve-roots as far as the second sacral vertebra, where they end blindly. The pia mater, however, since it invests the cord closely, ends as a tube where the cord ends, but some of its fibres are prolonged downwards as a slender glistening thread called the *filum terminale.* The filum pierces the lower ends of the arachnoid and the dura, and runs downwards to fuse with the periosteum on the back of the coccyx.

The *nerve-roots* are those of the five pairs of sacral nerves and the one pair of coccygeal nerves. The roots of the **upper four** sacral nerves pierce the arachnoid and dura, and unite to form the nerve-trunks in the lateral part of the sacral canal opposite the corresponding sacral foramina. Each *trunk* divides almost at once into an anterior and a posterior primary ramus. The *posterior primary rami* are small; they emerge through the posterior sacral foramina and sink into the muscles on the back of the sacrum; and the upper three of them send branches also to the skin of the gluteal region. The *anterior primary rami*—much thicker, but diminishing in size from above downwards—pass into the pelvis through the anterior sacral foramina and form the greater part of the sacral plexus and part of the coccygeal plexus. The roots of the **fifth** pair of nerves pierce the lower end of the meningeal tubes and unite in the lower part of the sacral canal; and their primary rami escape through the lower end of the canal. The roots of the **coccygeal** pair of nerves unite inside the tubes. Their trunks pierce the lower ends of the tubes and divide into primary rami, which escape with the rami of the fifth sacral. As the filum and the nerves pierce the arachnoid and the dura, they carry off sheaths from these membranes.

The structures transmitted by the lower end of the sacral canal are therefore the *filum terminale* and the primary rami of the *coccygeal* and *fifth sacral nerves.* The posterior rami of these two pairs of nerves supply the overlying skin; and they are so slender that the dissectors have probably not found them. Their anterior rami descend to the coccyx, curve forwards—the fifth under cover of the intercornual ligament and above the transverse process of the coccyx, and the coccygeal below the process—and pierce the sacro-tuberous and sacro-spinous ligaments and the coccygeus to enter the pelvis, where they form the greater part of the coccygeal plexus.

The dissectors will now clean the ligaments on the *right half* of the back of the pelvis.

> ***Dissection.***—Find the right *ilio-lumbar ligament* again, and clean it. Then, define and clean the ligaments on the back of the right *sacro-iliac joint*, removing the overlying muscles from them and from the right half of the back of the sacrum. Expose the posterior sacral foramina, and note the posterior primary rami and small vessels emerging through them. If the dissector of the Lower Limb has not cleaned the right *sacro-tuberous ligament* and defined its attachments, do so now, and look for small nerves and vessels that pierce it. Then, divide the ligament about its middle ; raise its pelvic part, and detach it carefully from the medial part of the *sacro-spinous ligament*, which it overlies ; look for small nerves between them. Define the margins of the sacro-spinous ligament, identify the *pudendal nerve*, which lies on its lateral part, and also the *internal pudendal vessels* and the *nerve to the obturator internus*, which lie more laterally—on the ischial spine—and have probably been cleaned and left in place by the dissectors of the gluteal region.

Vertebro-Pelvic Ligaments (Figs. 211, 212).—These important bands are the ilio-lumbar, sacro-tuberous and sacro-spinous ligaments.

The **ilio-lumbar ligament** is a strong triangular band that springs from the fifth lumbar transverse process and spreads out to be inserted into the inner lip of the iliac crest above the posterior part of the iliac fossa. It is concealed posteriorly by the sacro-spinalis and is overlapped anteriorly by the psoas major. Superiorly, it gives partial origin to the quadratus lumborum and fuses with the two layers of fascia that enclose the quadratus. It assists the intervertebral disc and the articular processes in preventing the last lumbar vertebra from subsiding into the pelvis under the weight of the trunk—the lumbo-sacral joint being very oblique.

The **sacro-tuberous ligament** is a long, strong band, wide at each end and narrower and thicker in the middle. It bridges across the gap that separates the hip-bone from the coccyx and lower part of the sacrum, forming the dorsal boundary of both of the sciatic foramina and one of the boundaries of the perineum and outlet of the pelvis. Its upper end is attached to the coccyx, the lower part of the sacrum and both of the posterior iliac spines. Its lower end is attached chiefly to the medial, lower part of the ischial tuberosity and partly to the ischial ramus by a thin, tapering prolongation, called its *falciform process*, whose upper edge is continuous with the obturator fascia. Inferiorly, the ligament is also partly continuous with the tendon of the long head of the biceps femoris—an indication that it was once the proximal part of that tendon.

Its superficial surface is covered by the part of the gluteus maximus that arises from it. Its deep surface is related, from above downwards, (1) to the piriformis, some of whose fibres spring from it, (2) to the sacro-spinous ligament, and (3) to the obturator internus tendon as it emerges through the lesser sciatic foramen. The ligament is pierced by small vessels and nerves:—(1) the coccygeal branch of the inferior gluteal artery, (2) the perforating cutaneous nerve, (3) the coccygeal and fifth sacral nerves, and (4) branches of the coccygeal plexus.

The **sacro-spinous ligament** is a thin, flat, triangular sheet whose lateral part separates the two sciatic foramina, forming a small part of the boundary of each of them. Its narrow end is attached to the ischial spine, and it widens medially to be attached to the last piece of the sacrum and the first piece of the coccyx. It is the fibrosed dorsal layer of the coccygeus muscle; the dissectors, having defined the ligament, can have no doubt about the position and extent of the coccygeus muscle: the muscle is fused with the pelvic surface of the ligament and is coextensive with it. The lateral part of the dorsal surface of the ligament is crossed by the pudendal nerve. The medial and larger part is covered by the sacro-tuberous ligament (which, in turn, is covered by the gluteus maximus); and portions of the perforating cutaneous nerve and perineal branch of the fourth sacral nerve, as they descend to the perineum, may be found between the two ligaments.

Both the ligaments and the coccygeus are pierced by the fifth sacral and coccygeal nerves and branches of the coccygeal plexus.

The sacro-tuberous and sacro-spinous ligaments provide boundaries for the perineum and the sciatic foramina, and the sacro-tuberous ligament gives attachment to muscles; but their chief function is to assist in keeping the sacrum and coccyx in position. For the weight of the trunk falls on the anterior part of the sacrum; the base of the sacrum therefore tends to be driven downwards and the apical part and the coccyx to be tilted upwards; these ligaments help to prevent that displacement.

The pudendal vessels and nerves and the nerve to the obturator internus have been identified already. The proximal parts of the other structures transmitted by the sciatic foramina should now be examined.

Dissection.—Identify the tendon of the *obturator internus* in the lesser foramen, and then the *piriformis* muscle in the greater. Find the remaining parts of the vessels and nerves that emerge above and below the piriformis. If the piriformis and these vessels and nerves are in any way adherent to the margins of the foramen, set them free, in order that they may not be torn away when the hip-bone is removed at a later stage.

Sciatic Foramina (Figs. 211, 212).—The **greater sciatic foramen** is a wide opening bounded by the greater sciatic notch of the hip-bone and the sacro-tuberous and sacro-spinous ligaments. It transmits:—(1) the piriformis muscle; (2) one set of vessels and a nerve above the piriformis; and (3) six nerves and two sets of vessels below it.

The *piriformis* almost fills the foramen. The nerve and vessels above it are the *superior gluteal.* The largest of the nerves below it is the *sciatic*—the thickest nerve in the body, and easily identified. Lift it up and find a slender nerve under cover of it—the *nerve to the quadratus femoris.* The *inferior gluteal vessels* and *nerve* are close to the medial side of the sciatic nerve or on its posterior surface. The *posterior cutaneous nerve of the thigh* lies near them; it is a much longer nerve than the inferior gluteal, but at this stage it may not be easily distinguished from the inferior gluteal unless the dissector of the Lower Limb has cut it low down. The *nerve to the obturator internus* and the *internal pudendal vessels* and the *pudendal nerve* are a finger's breadth medial to the sciatic nerve, and have been seen already.

The **lesser sciatic foramen** is below and behind the greater. It is bounded by the lesser sciatic notch and both ligaments. The tendon of the *obturator internus,* emerging through it, nearly fills it. The *nerve to the obturator internus,* the *internal pudendal vessels* and the *pudendal nerve* emerge from the pelvis through the greater foramen and pass through the lesser foramen into the perineum, where they have been dissected already.

The dissectors will now make a preliminary survey of the pelvic viscera and peritoneum; the dissectors of the **female pelvis** *will find the general position of the viscera described on p.* 411.

General Position of Viscera in the Male

The upper part of the *pelvic colon* can usually be lifted out of the pelvis, but the lower part is attached to the dorsal wall by the medial limb of the *pelvic mesocolon*. The *rectum* occupies the lower portion of the dorsal part of the cavity and follows the concavity of the sacrum and coccyx

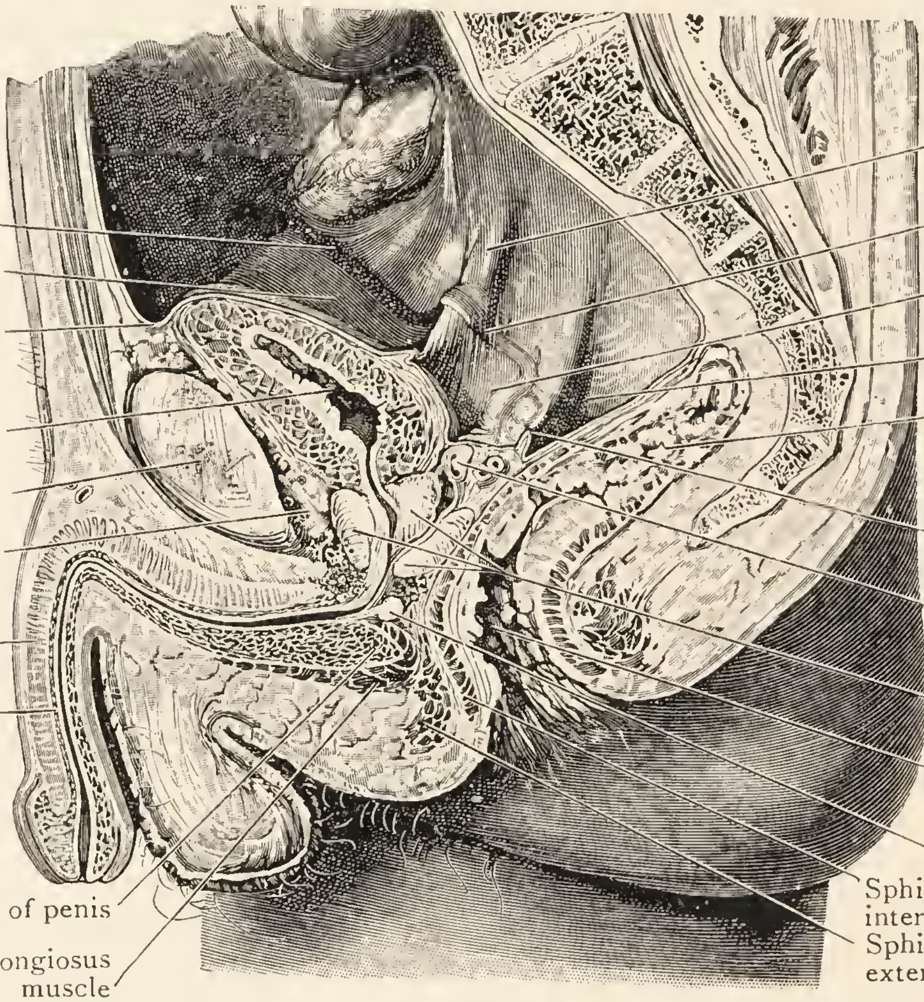

Fig. 204.—Median Section of a Male Pelvis. The Bladder, which is empty, does not present the usual form.

(Figs. 204, 205). The *urinary bladder* lies in the lower and anterior part of the cavity, behind the pubic bones. The *ureters* can usually be seen shining through the peritoneum far back on the side walls of the pelvis; they descend with a curve to the back of the bladder. The *seminal vesicles* lie on the back of the bladder, between it and the rectum. On each side, the *vas deferens* also can usually be seen shining through the peritoneum as it runs from the deep inguinal ring towards the bladder; having crossed the brim, it runs first downwards and backwards, and then medially across the ureter, to reach the back of the bladder, where it descends along the medial side of the seminal vesicle, close to its fellow of the opposite side. The *prostate* lies below the bladder immediately in front of the

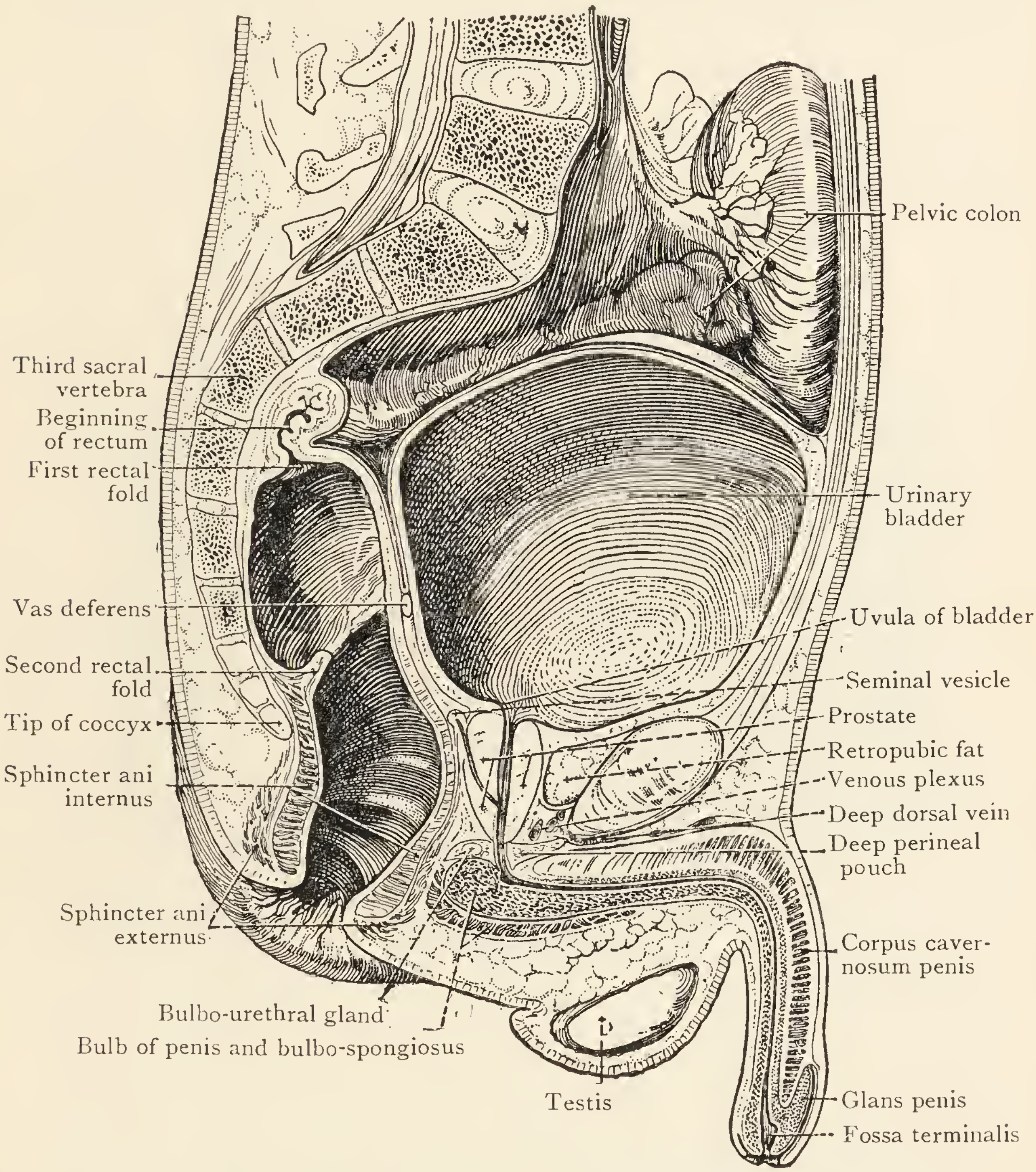

FIG. 205.—Median Section of a Male Pelvis. The Bladder and Rectum are distended.

lowest part of the rectum, and it encloses the *prostatic part of the urethra* (Fig. 205).

Pelvic Peritoneum.—The peritoneum of the posterior wall of the abdomen enters the pelvis at the brim. It covers the dorsal wall of the pelvis, and, as it descends, it is reflected off as the medial limb of the pelvic mesocolon. At the third piece of the sacrum, it reaches the rectum, to which it gives a partial covering: it covers the front of the upper third of the rectum and also its sides, but to a gradually diminishing extent, till, at the middle third, it covers only the anterior

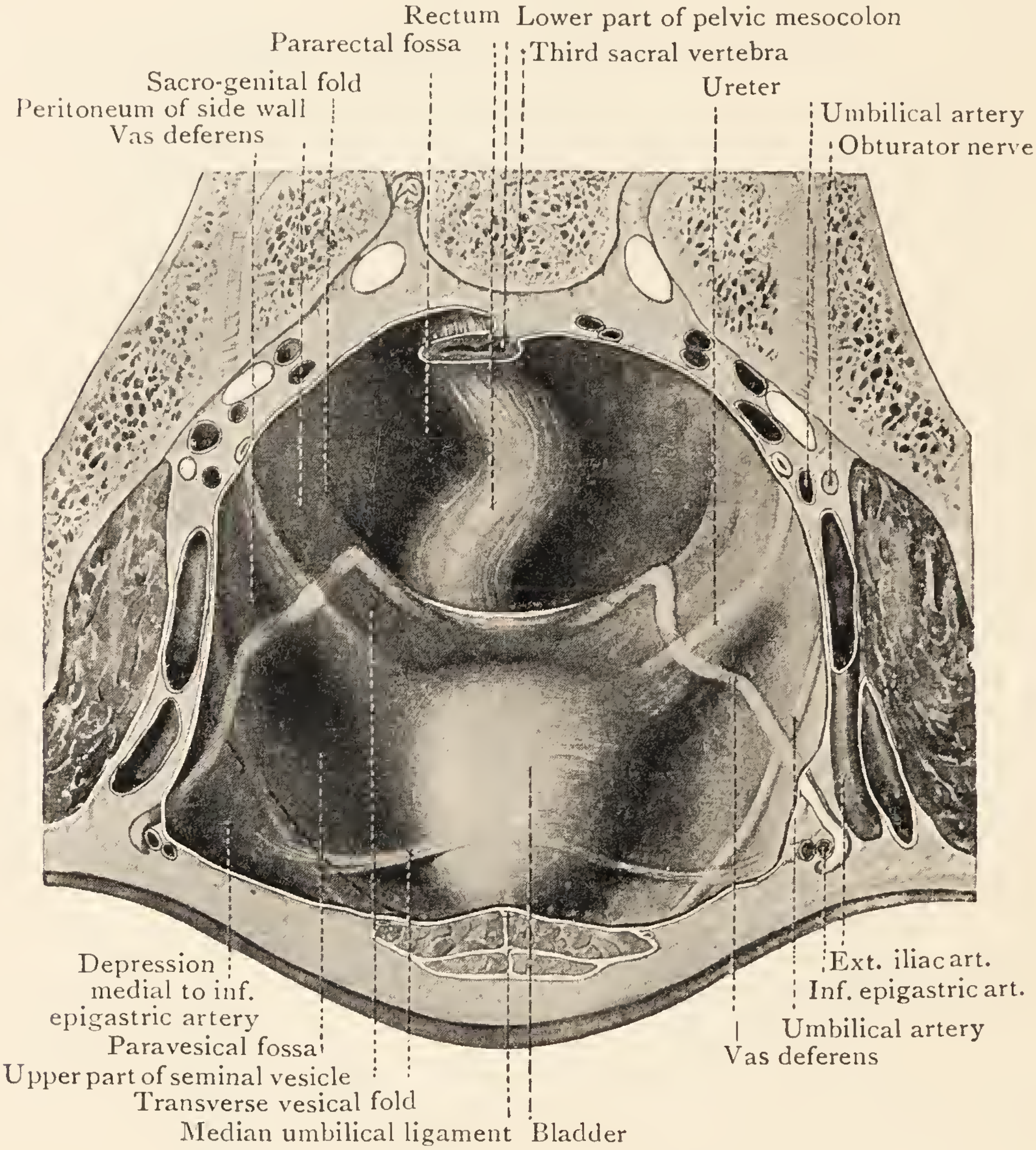

FIG. 206.—Peritoneum of True Pelvis in the Male.

The upper part of the dorsal wall of the true pelvis has been removed to show more clearly the disposition of the peritoneum within its cavity. (Dixon and Birmingham)

surface; and, when the lower end of the middle third is reached, it passes from the rectum to the bladder. It covers the upper surface of the bladder, from which it passes forwards on to the anterior abdominal wall and sidewards to the pelvic walls.

From the sides of the upper third of the rectum, it extends to the side walls of the pelvis—forming the floors of a pair of depressions called the *pararectal fossæ.* As it passes forwards from the rectum to the bladder it forms the floor of a depression known as the *recto-vesical pouch* ; the peritoneal floor of this pouch is three inches or less from the skin of the perineum—a point of importance, for in some operations on the pelvis through the perineum care has to be taken to avoid injury to the peritoneum. When the peritoneum reaches the bladder, it is usually tucked down behind it to cover a small portion of its posterior surface in the median plane between the two vasa deferentia.

If the bladder is empty, certain minor points may be noted. The upper end of the seminal vesicle and the related part of the vas raise up a blunt ridge of peritoneum; it curves backwards towards the sacrum and is called the *sacro-genital fold.* As the peritoneum sweeps sidewards from the bladder it forms the floors of a pair of shallow depressions sometimes termed the *paravesical fossæ.* Occasionally, it is raised up in the floor of each fossa and on the upper surface of the bladder into a slight ridge called the *transverse vesical fold.*

The dissectors of the male pelvis *will now pass to the study of the retropubic space and the dissection to divide the pelvis* (*p.* 417).

General Position of Viscera in the Female

The *pelvic colon* is usually sufficiently movable for a great part of it to be lifted out of the pelvis; but its lower part is bound to the dorsal wall of the pelvis by the medial limb of the *pelvic mesocolon*, which is sometimes very short. The *rectum* occupies the lower portion of the dorsal part of the cavity and ends inferiorly in the *anal canal.* The *urinary bladder* is farthest forward, lying against the pubic bones, more or less hidden below the peritoneum ; and the *urethra* curves downwards and forwards from its lowest part, which is called its *neck* (Figs. 208, 209).

The *uterus* stands up prominently between the rectum and the bladder, and overhangs the bladder; its rounded, free end is called its *fundus*; the adjoining two-thirds is its *body*; the remaining third is its cervix or *neck*, and the neck is inserted into the vagina. The *vagina* extends downwards and forwards from the uterus and is hidden below the peritoneum. There are thus three canals directed downwards to open on the surface in the perineum—the rectum, the vagina, and the urethra (Fig. 207).

The *broad ligament* is the fold of peritoneum that stretches from the uterus to the side wall of the pelvis; the *ep-oöphoron* consists of minute tubules between its layers; the *round ligament*, also within the broad ligament, raises up a ridge on its lower surface, and can be seen shining through the peritoneum as it runs from the broad ligament towards the deep inguinal ring; the *ligament of the ovary* raises a ridge on the upper surface; and the *uterine tube* lies in the anterior, free edge of the broad ligament. The *ovary* is attached to the upper surface of the broad ligament near the side wall of the pelvis.

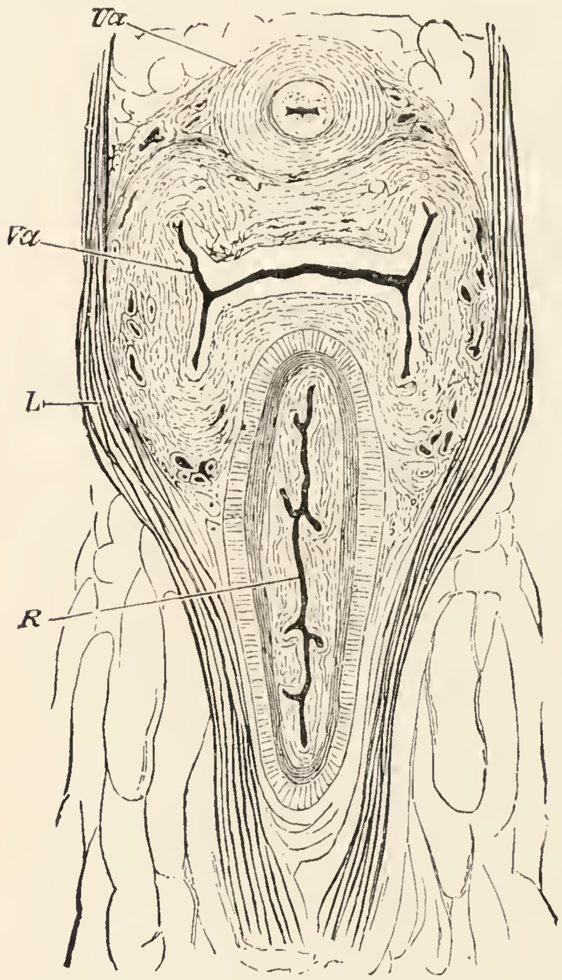

FIG. 207.—Horizontal Section through Urethra, Vagina, and Anal Canal, a short distance above their terminations. (Henle)

Ua. Urethra. | *L.* Levator ani.
Va. Vagina. | *R.* Anal canal.

The *ureter* can be seen through the peritoneum far back on the side wall of the pelvis; farther forwards, it disappears as it curves below the broad ligament to reach the bladder.

Pelvic Peritoneum.—The peritoneum extends downwards from the posterior wall of the abdomen over the pelvic brim into the pelvis. As far as the third piece of the sacrum, it clothes the dorsal wall as a continuous sheet, except along the root of the medial limb of the pelvic mesocolon, where it is reflected off the sacrum as the two layers of that fold. At the third piece of the sacrum, the mesocolon ends, and the peritoneum is spread over the front and sides of the rectum, and over the dorsal wall of the pelvic cavity on each side of it, forming the floors of a pair of depressions called the *pararectal fossæ.* As these fossæ are traced downwards, they become shallower, and disappear at the level of the junction of the upper and middle thirds of the rectum, for the peritoneum gradually covers less and less of the sides of the rectum till, at the middle third, it covers only the front of it.

At the junction of the middle and lower thirds of the rectum, the peritoneum leaves the rectum and the dorsal wall of the pelvis and curves forwards to the back of the vagina and the roots of the broad ligaments. It then extends forwards:—(1) as the upper layer of the broad ligament on each side, and (2) over the uppermost part of the back of the vagina and the upper or intestinal surface of the uterus. Curving over the fundus of the uterus and the free edge of each broad ligament, it now passes backwards as the lower layer of the ligament and over the lower or vesical

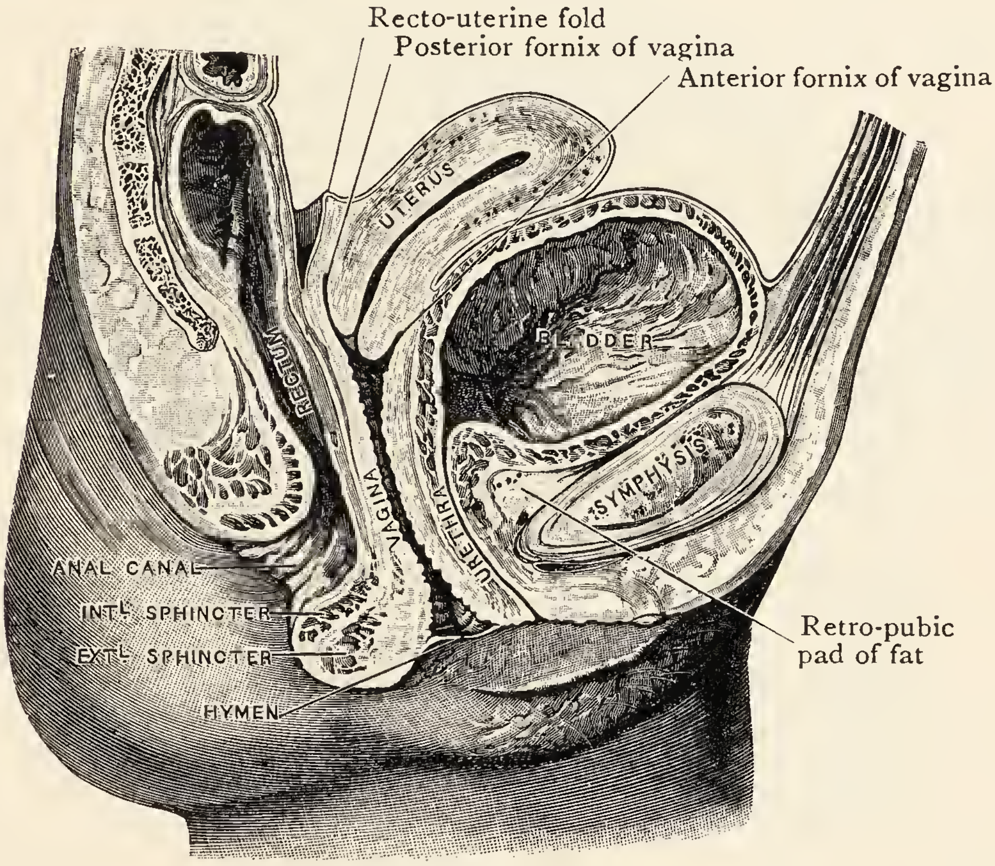

FIG. 208.—Median Section through Female Pelvis.

surface of the uterus and is then reflected forwards to cover the upper surface of the bladder. When the bladder is empty, it forms also the floor of a shallow depression at each side of the bladder called the *paravesical fossa*. From the bladder (and the paravesical fossæ) it passes on to the anterior wall of the abdomen and the side wall of the pelvis.

As the peritoneum sweeps forwards from the rectum to the vagina it forms the floor of a depression called the recto-vaginal or *recto-uterine pouch*. There is nothing in the anatomy of the female pelvis more important than the fact that the lower part of this pouch is "recto-vaginal." Pass the finger into the vagina and prove the fact that the peritoneum clothes the uppermost part of the back of the vagina for at least a quarter of an inch, and that the cavity of the vagina is therefore in close proximity to the peritoneal cavity. At the same

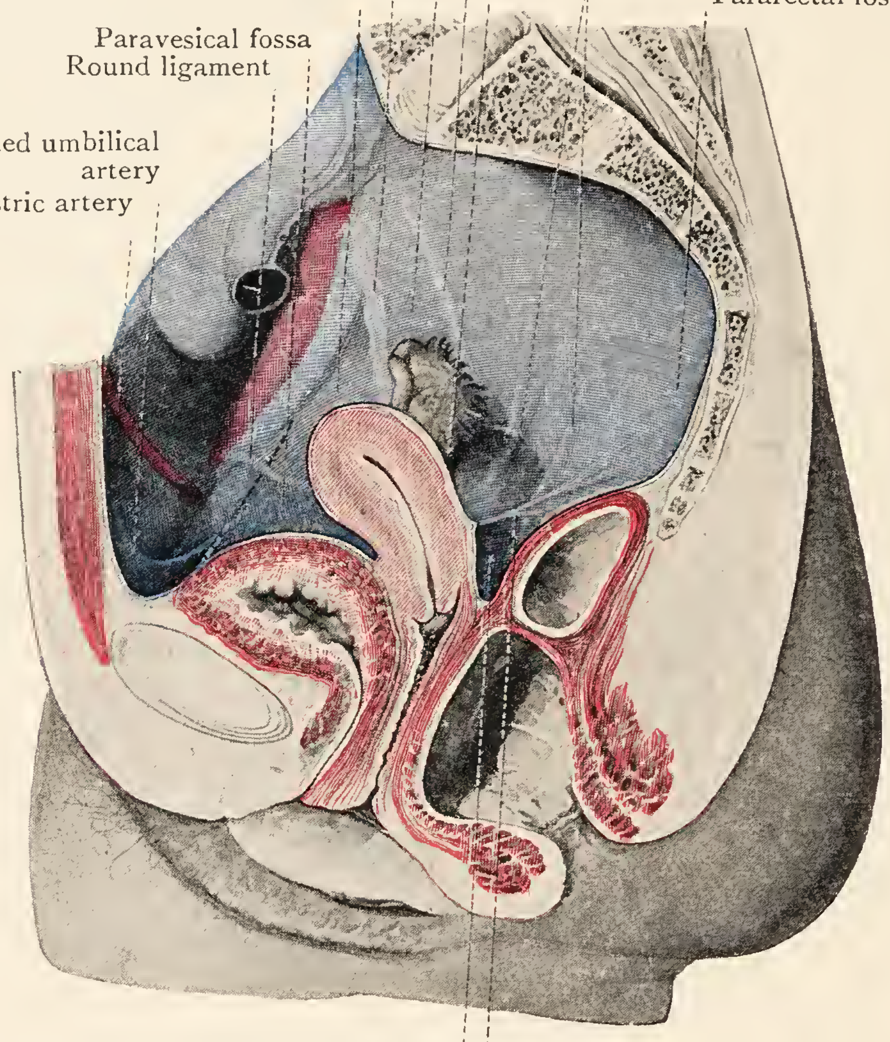

FIG. 209.—Median Section through Female Pelvis to show the disposition of Peritoneum in relation to Viscera and to Side Wall of the Cavity. (Dixon and Birmingham)

time, gauge the distance of the floor of the pouch from the skin of the perineum in front of the anus; usually it is little more than two inches—the distance between the peritoneum and the skin of the perineum being less in the female than in the male.

On the vesical surface of the uterus, the peritoneum extends down only to the junction of its body and neck and is then reflected on to the bladder, forming the bottom of a narrow recess called the *utero-vesical pouch.*

In specimens in which the viscera and fascia have been hardened, a ridge of peritoneum may be seen on the back of the neck of the uterus, and on each side it is continuous with a ridge or fold that curves backwards to the sacrum at the side of the rectum; this ridge is called the *recto-uterine fold*; when present, it forms a lateral boundary to the recto-uterine pouch, and is caused by an underlying fibro-muscular band called the *utero-sacral ligament* that stretches from the neck of the uterus to the sacrum.

Broad Ligament of Uterus.—The dissectors should now examine the **broad ligament** of the uterus (Figs. 210, 221, 237). Some of the structures to which it is related will be

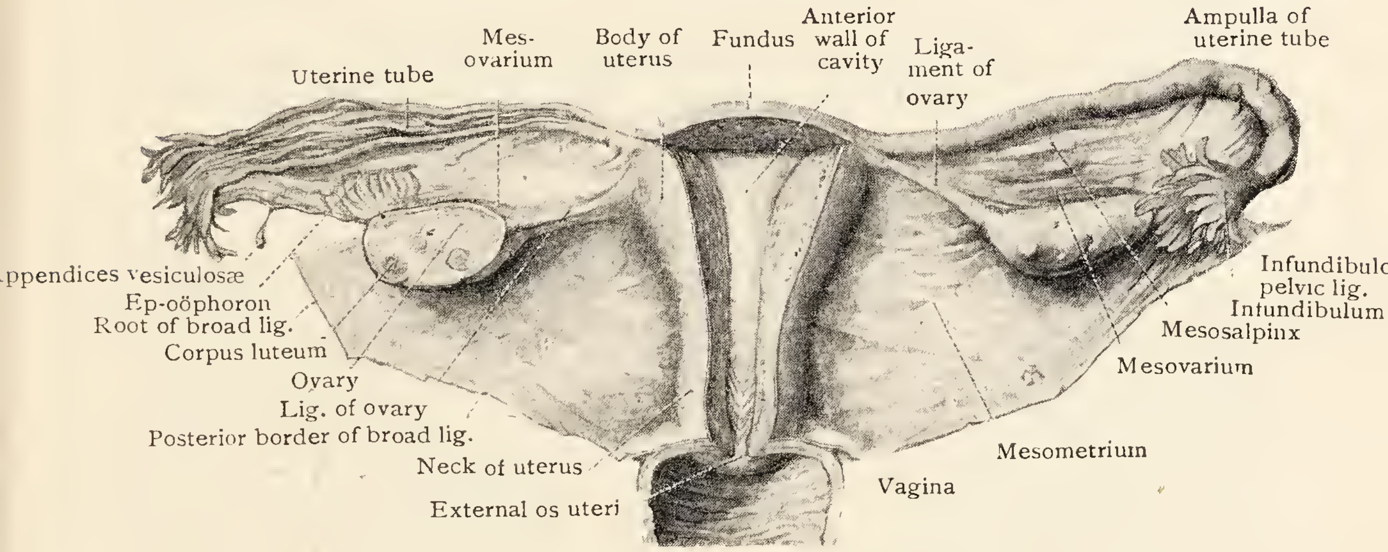

FIG. 210.—Uterus, Uterine Tubes, Ovaries, Broad Ligaments, and upper part of Vagina, seen from behind. Vagina, Uterus, and Left Uterine Tube have been laid open.

exposed when the dissection of the interior of the pelvis is begun, but many of them can be palpated now.

The two layers of the ligament are continuous with each other anteriorly, forming its free *anterior border.* In its medial four-fifths, the anterior border contains the uterine tube, which extends laterally from the fundus of the uterus and, near the side wall of the pelvis, opens into the peritoneal cavity through the upper layer of the ligament; the terminal part of the tube is called the infundibulum. The lateral fifth of the anterior border of the ligament is called the *infundibulo-pelvic ligament*; it extends on to the external iliac vessels and spreads out to become continuous with the peritoneum that clothes them; at this point the ovarian vessels cross the iliac vessels, enter the ligament, and descend to the ovary.

The *posterior border* or *root* of the broad ligament is attached to the upper part of the side of the vagina and to the fat on the floor of the pelvis above the levator ani. At this border, the two layers of the ligament separate from each other and are continuous with the peritoneum of the pararectal and paravesical fossæ. The ureter passes forwards below the root, close to the vagina. The uterine artery (with its plexiform companion veins) runs forwards in the fat from the internal iliac artery to the root of the ligament, passes in between its two layers, curves medially above the ureter and then runs tortuously along the side of the uterus.

At the *medial border* of the ligament, its two layers are attached to the side of the uterus and separate to become continuous with the peritoneum on its two surfaces.

The *lateral border* is attached to the side wall of the pelvis about an inch below (or in front of) the ureter, and the two layers separate to become continuous with the peritoneum of the side wall; the line of attachment begins at the external iliac vessels and crosses the umbilical artery and the obturator nerve and vessels.

The *lower surface* of the broad ligament is related to a loop of intestine, or to the bladder as it fills.

The *upper surface* is related to intestine, and it gives attachment to the ovary near the side wall of the pelvis. The two exceedingly short layers of peritoneum that connect the ovary with the broad ligament are given the name *mesovarium*.

The portion of the broad ligament that stretches from the attachment of the ovary to the uterine tube is called the *mesosalpinx* (*salpinx* means a tube).

Note that as the bladder fills, the uterus and the broad ligament are pushed up by it till their surfaces become anterior and posterior.

The following are the contents of the broad ligament—most of which will be described later :—

1. Extraperitoneal fatty tissue; it is most abundant near the side of the uterus, where it is called the *parametrium*.
2. The uterine tube, in the free edge of the ligament.
3. The round ligament of the uterus, which raises a ridge on the lower surface of the broad ligament.

4. The ligament of the ovary, which raises a ridge on the upper surface.
5. The uterine vessels and nerves, near the side of the uterus.
6. The ovarian vessels and nerves, near the side wall of the pelvis.
7. Lymph-glands (and associated lymph-vessels), near the veins.
8. Minute, tubular developmental vestiges called the ep-oöphoron.

Retropubic Space and Division of Pelvis

The dissectors of either the **male pelvis** *or the* **female pelvis** *now proceed to explore the retropubic space.*

Retropubic Space.—This space is the interval that separates the bladder from the front and side walls of the pelvis, and it is occupied by a quantity of loose extra-peritoneal fat called the *retropubic pad of fat.* Pass the finger downwards through the fat between the bladder and the body of the pubis close to the symphysis till a strong, resisting fibrous band is met. This band is the *medial pubo-prostatic ligament* (*pubo-vesical* in the female), which extends from the body of the pubis to the neck or lowest part of the bladder and the base or upper part of the prostate. The ligament will be examined later.

Now pass the finger sidewards and backwards between the bladder and the pelvic wall, and it will be found that the finger can pass easily through the fat as far as the ureter, where it is stopped owing to the close manner in which the peritoneum adheres to the ureter. The floor of the space is formed of the pubo-prostatic (or pubo-vesical) ligaments and the fascia on the pelvic surface of the levatores ani. Superiorly the space extends beyond the pelvis between the peritoneum and the fascia transversalis as far as the umbilicus ; this extension is bounded on each side by the lateral umbilical ligament. If the front of the bladder is ruptured, the urine is poured into the retropubic space. The floor limits its downward trend ; sidewards, it cannot pass beyond the ureters ; and it therefore mounts up in the extraperitoneal tissue of the anterior abdominal wall.

Division of Pelvis.—Dissection can be carried out to a certain extent on the interior of the undivided pelvis, but the process is hampered and soon brought to a stop by lack of space to work in. It is not possible to make a complete display of all the structures in turn on both sides of one pelvis, and the dissectors of the two sides should agree to make a partial sacrifice of one half. The least sacrifice is entailed if the right hip-bone is removed with the structures attached and adhering to it. Before the actual disarticulation of the bone is attempted, the dissectors must identify a large number of structures and make a fairly extensive dissection to expose them ; and the whole process requires both care and patience.

If the students are dissecting the pelvis for the second time, they may vary the procedure in the region of the symphysis and expose the organs from the front in the way indicated in Fig. 213 and either Figs. 218 and 231 or Figs. 221 and 237. If they are dissecting it for the first time, they should proceed as follows.

Dissection.—The dissection must be carried out on the *right side.*

In a male pelvis : Divide the right *vas deferens* near its entrance into the pelvis. Strip the *peritoneum* from the pelvic brim medially towards the viscera, moving the *ureter* and the vas deferens with it.

In a female pelvis : Divide the right *ovarian vessels* and *round ligament* of the uterus near their entrance into the pelvis. Detach the *peritoneum* from the brim, raise it and push it towards the viscera, taking the *round ligament*, the *ovary*, the *broad ligament* and its contents with the peritoneum.

In either male or female pelvis, after the peritoneum is stripped up, proceed as follows :—Cut the *common iliac vessels* at their middle. Detach the *psoas major* completely, push it laterally, and divide the *ilio-lumbar ligament.* Define and clean the *lateral lumbo-sacral ligament*, which connects the last lumbar transverse process with the ala of the sacrum ; but leave it in place. Cut the *obturator nerve* as it emerges from the psoas ; strip the periosteum off the ala of the sacrum till the *abdominal surface of the sacro-iliac joint* is reached, and then cut through the ligament of the joint along the margin of the ala. Trace the *lumbo-sacral trunk* into the pelvis. Trace also the *internal iliac artery* into the pelvis and follow its two divisions until they begin to give off branches. The first branch of the posterior division is the *ilio-lumbar*, which ascends into the abdomen. Cut the *posterior division* below the origin of the ilio-lumbar (or, if the ilio-lumbar arises from the internal iliac trunk, cut the posterior division near its upper end). Cut the *anterior division* below the origin of its first two branches—the *umbilical* and the *obturator.*

The anterior primary ramus of the *first sacral nerve* will be found below the posterior division of the artery, close to the upper part of the *piriformis* ; clean the nerve, and define the upper part of the muscle ; push the artery, nerve and muscle downwards and the lumbo-sacral trunk upwards to expose the *pelvic surface of the sacro-iliac joint* ; clean the narrow ligament that closes the joint, and then incise it along the line of the joint.

It may be difficult to find the line of the joint : examine a dried pelvis and then gauge the position of the joint in the specimen under dissection.

Now, identify the *levator ani* from the perineum, where it has been exposed already. Then, pass the fingers down along the side wall of the pelvis and scrape away as much fat as possible from the pelvic surface of the levator—removing the fat entirely or pushing it medially.

Turn to the back of the pelvis. Divide the *nerve to the obturator internus*, the *internal pudendal vessels* and *pudendal nerve* as they emerge through the greater sciatic foramen ; if they are adherent to the underlying bone and ligament, release them, and then divide the *sacro-spinous ligament* and the *coccygeus*, medial to the pudendal nerve.

Next, with a stout knife, divide the *posterior* and *interosseous ligaments of the sacro-iliac joint*. The interosseous ligament is short and very thick. Examine the dried pelvis again to gauge the position of the joint from the back, and examine the articular surface of a separate hip-bone or a separate sacrum and compare it with the specimen, in order to gauge the thickness of the interosseous ligament.

Now, turn to the front of the pelvis. Detach the *suspensory ligament of the penis* (or *clitoris*) from the front of the *pubic symphysis*. If the *right crus* of the organ is still attached to the side of the pubic arch, detach it and push the organ over to the left side ; and divide the remains of the deep transversus perinei and sphincter urethræ.

Clean the *ligaments of the symphysis*. Divide the pubic symphysis accurately in the median plane, and separate the pubic bones slightly. Next, while your partner holds the pubic bones slightly apart, push back the bladder, remove the loose tissue between the right and left *medial pubo-prostatic* (or *pubo-vesical*) ligaments, and divide the right ligament. Then, from the perineum, divide the right *levator ani* and the fascia that covers it—carrying the knife first laterally behind the pubis and then backwards near the side wall of the pelvis, and ending at the point where the coccygeus and sacro-spinous ligament were divided.

The right hip-bone is now free (or nearly so), and should be wrenched off with the structures attached to it ; the dissectors will probably find that a touch or two of the knife is still required in the region of the sacro-iliac joint, and that considerable force is required to remove the bone.

Joints of the Pelvis

As the dissectors have exposed two of the most important joints of the pelvis, they will study the pelvic joints now, before the ligaments become dry. They will replace the right hip-bone from time to time as they study the two joints now exposed—the pubic symphysis and the sacro-iliac joint.

The **pelvic joints** are :—(1) The *lumbo-sacral joints*, by which the pelvis is united to the last lumbar vertebra ; (2) the *sacro-coccygeal joint* and (3) *coccygeal joints*, which complete the series of intervertebral joints; (4) the *sacro-iliac joints*, by which the hip-bones articulate with the vertebral column; and (5) the *pubic symphysis*, by which the hip-bones are united to each other (Figs. 211, 212, 213).

In addition to the ligaments of these joints, there are also

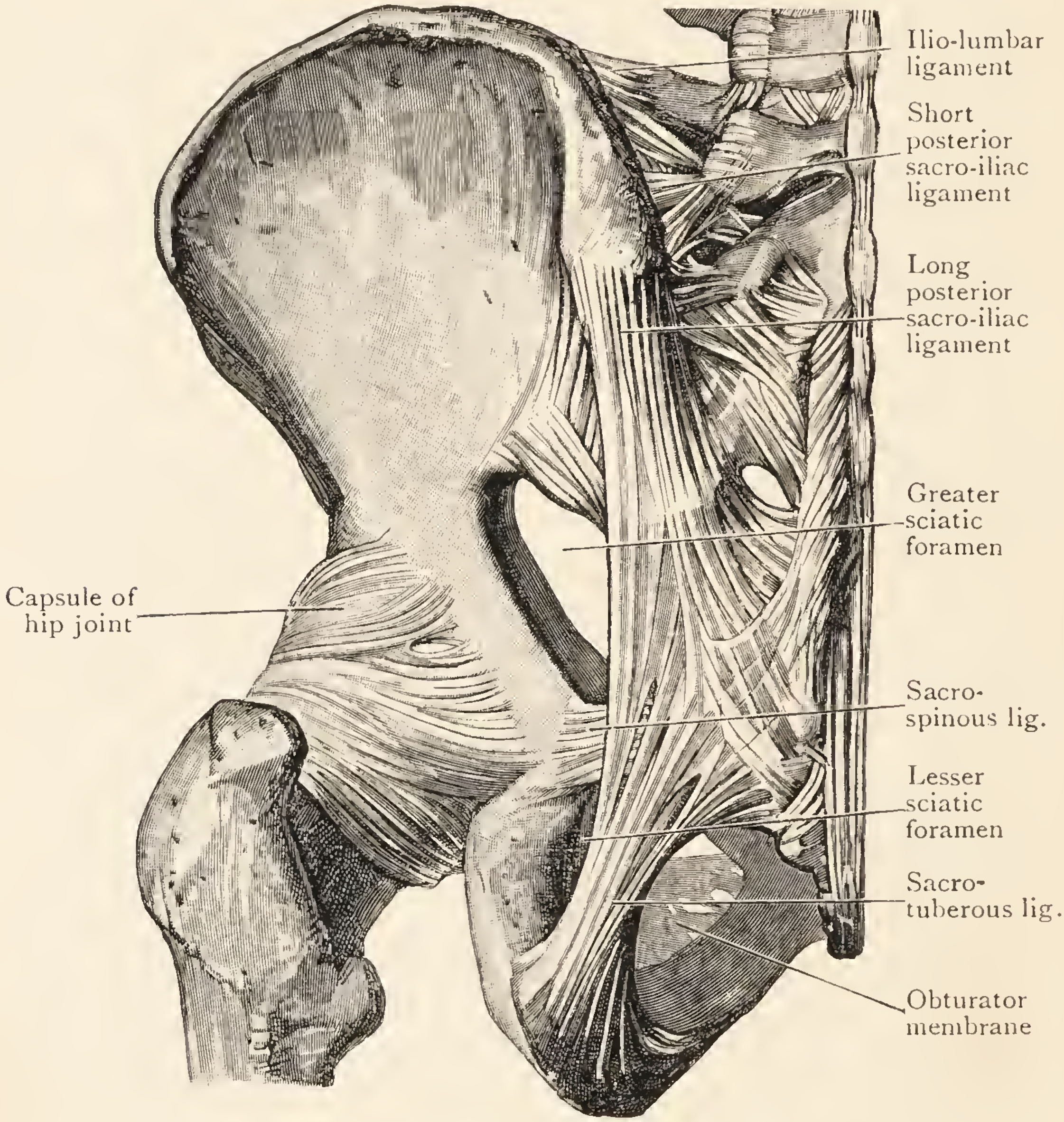

FIG. 211.—Dorsal view of Pelvic Ligaments and of Hip Joint.

the three pairs of vertebro-pelvic ligaments which have been described already—the *ilio-lumbar*, which is accessory to the lumbo-sacral joints; and the *sacro-tuberous* and *sacro-spinous*, accessory to the sacro-iliac joints.

Lumbo-Sacral Joints.—These joints are like those between two lumbar vertebræ (p. 397), the lumbar intertransverse ligament being represented by a triangular band, called the *lateral lumbo-sacral ligament*, which stretches downwards behind the psoas from the last lumbar transverse process to the lateral part of the ala of the sacrum. It may be noted also that, since the segments of the sacrum are fused together, the longitudinal ligaments end by fusing with the periosteum on the front and back of the first sacral body.

Common Lumbo-Sacral Variations.—Examine the last lumbar vertebra and the first piece of the sacrum in the pelvis under dissection and compare them with the corresponding bones in the skeleton of a normal pelvis. It is not uncommon to find that the fifth lumbar vertebra or its transverse process is partly fused with the sacrum, or that the first sacral vertebra is partly separated from the rest of the sacrum. Such variations are often asymmetrical ; and they are sometimes the cause of pressure on nerves.

Sacro-Coccygeal Joint.—At this joint there are :—(1) an intervertebral disc, (2) one anterior and two posterior sacro-coccygeal ligaments, (3) a pair of lateral sacro-coccygeal ligaments, and (4) a pair of intercornual ligaments.

The body of the fifth sacral vertebra is united to the first piece of the coccyx by the *intervertebral disc* and by an *anterior* and a *deep posterior sacro-coccygeal ligament*, which cover the front and the back of the disc and correspond to the longitudinal ligaments in higher regions. The *superficial posterior ligament* extends from the dorsal margins of the lower end of the sacral canal to the back of the coccyx, and corresponds to ligamenta flava and interspinous and supraspinous ligaments fused together. Each *intercornual ligament* unites a sacral cornu with a coccygeal cornu ; occasionally, it is ossified. Each *lateral sacro-coccygeal ligament* connects the inferior lateral angle of the sacrum with the transverse process of the coccyx, making a lateral boundary for a fifth sacral foramen ; it is difficult to isolate it from the fibres of the sacro-tuberous and sacro-spinous ligaments. The anterior primary ramus of the fifth sacral nerve passes laterally under cover of the intercornual ligament, and then forwards through the foramen on the medial side of the lateral ligament—which is sometimes ossified, and then the foramen has complete bony boundaries.

Coccygeal Joints.—They are found in young subjects, in whom the segments of the coccyx are still united by *intervertebral discs* and *anterior* and *posterior ligaments*.

Sacro-Iliac Joint.—The sacro-iliac joint is a very important joint in the mechanism of the pelvis, and its ligaments are therefore very strong. The sacrum is wedged in between the two hip-bones, and on each side its *auricular surface* articulates with the auricular surface of the ilium to form a synovial joint. The weight of the trunk tends to drive the sacrum downwards, but it is held fast in its position chiefly by the ligaments of the joint and partly by the reciprocal sinuosities of the auricular surfaces. It has been explained already that the weight of the body falling on the base of the sacrum tends to tilt the apical part upwards, and that this is prevented by the sacro-tuberous and sacro-spinous ligaments.

Ligaments of Sacro-Iliac Joint.—The ligaments of the joint are anterior, posterior and interosseous.

The *anterior sacro-iliac ligament* is a ribbon of short transverse fibres that pass between the convex margins of the two auricular surfaces.

The *interosseous sacro-iliac ligament* is very thick; it has only one rival in strength, and that is the ilio-femoral ligament of the hip joint. It passes between the wide, rough areas that adjoin the concave margins of the auricular surfaces, and it closes the dorsal side of the joint.

The *posterior sacro-iliac ligaments* lie on the back of the interosseous ligament and are blended with it. They consist of:—(1) short transverse and oblique bundles of great strength that pass from the ilium to the first and second transverse tubercles on the back of the sacrum; and (2) a longer and more vertical band that passes from the posterior superior iliac spine to the third and fourth transverse tubercles, and blends laterally with the sacro-tuberous ligament.

Relations.—The relations of the sacro-iliac joint are important. Its *dorsal surface* is covered by the sacro-spinalis and the gluteus maximus. Note that the posterior superior iliac spine overhangs the joint and is opposite its centre, which is therefore opposite the skin-dimple that marks the position of the spine. Note further that the posterior inferior spine is at the posterior end of the joint, and that here the joint is very superficial and accessible, its ligaments being covered only by skin, fasciæ and a few fibres of the gluteus maximus.

Bring the two parts of the pelvis together again, and replace the structures related to the abdominal and pelvic surfaces of the joints as their relations are studied.

The antero-superior or *abdominal surface* is covered by the iliacus and psoas; the ilio-lumbar artery and the obturator nerve are close relations; and the femoral nerve is separated from it only by some fibres of the iliacus.

The *pelvic surface* is crossed by the lumbo-sacral trunk, the first sacral nerve and the upper part of the piriformis. The relation to vessels is variable. Usually the lower part of the internal iliac vein is related to the joint above the lumbo-sacral trunk; the posterior division of the artery

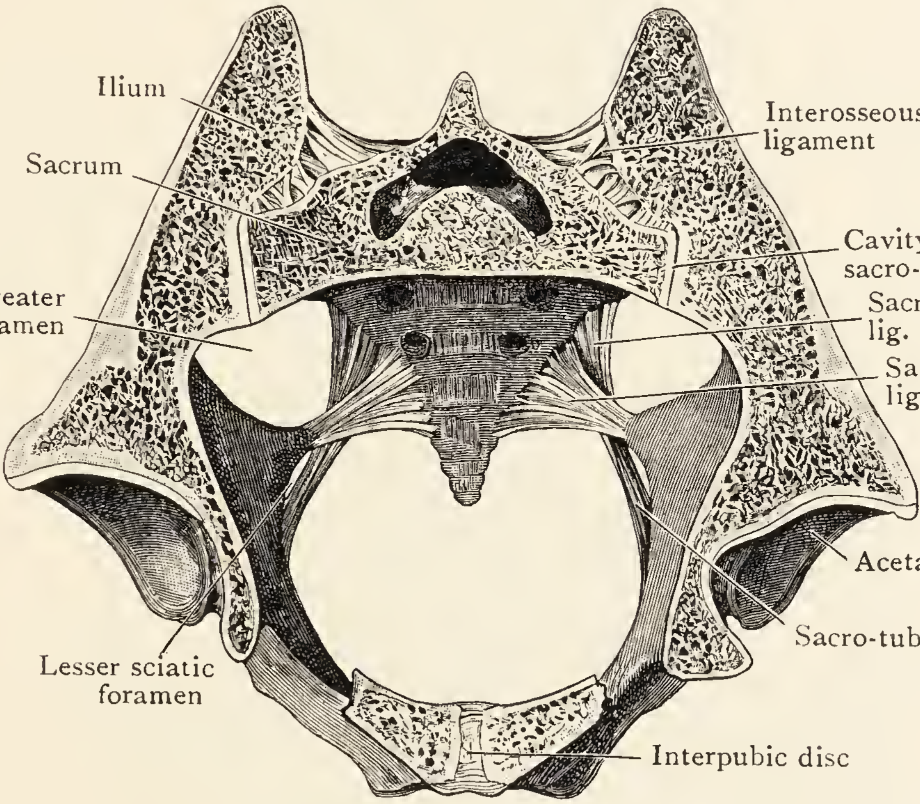

FIG. 212.—Coronal Section through True Pelvis.

is separated from the joint by the trunk; and the superior gluteal vessels lie across the joint between the trunk and the first sacral nerve. The relation to the nerves is of the most importance, for irregularities of the surface of a diseased sacro-iliac joint may exert injurious pressure on the nerves. The pain resulting from such pressure is felt not in the pelvis but somewhere below the knee in the cutaneous distribution of nerves that arise from the lumbo-sacral trunk and anterior primary ramus of the first sacral nerve; the tingling felt in the little finger when the ulnar nerve receives a blow at the elbow is a similar and more familiar instance of sensation felt at some distance from the seat of an injury.

Movements.—Although the sacro-iliac joint is a synovial joint, the unevenness of the auricular surfaces and the tightness of the ligaments make movement negligible—a slight rotation as the trunk is bent forwards and straightened again. By slight yielding they lessen shocks transmitted from the lower limbs through the pelvis to the backbone.

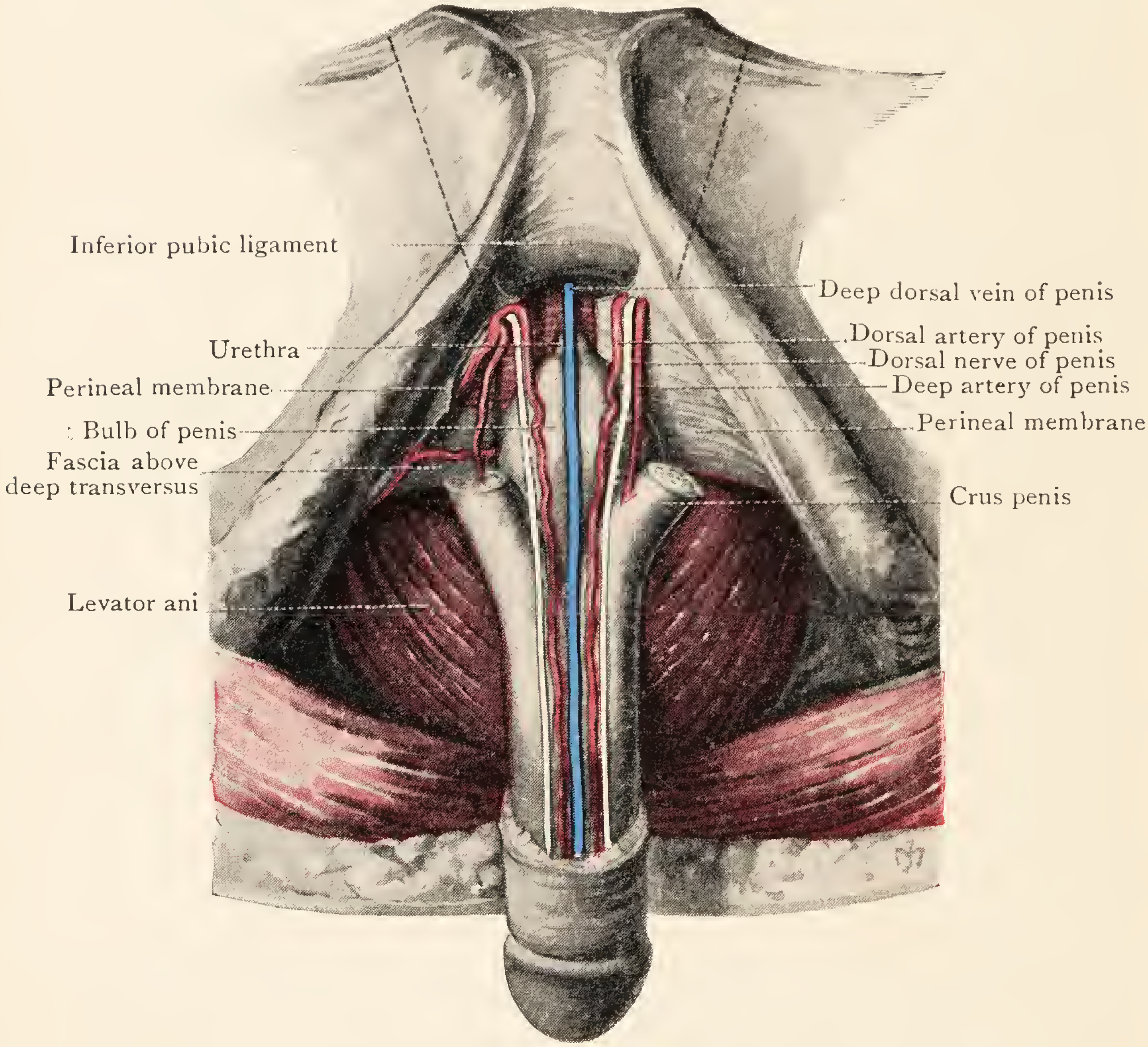

FIG. 213.—Dissection to show Pubic Symphysis and Dorsal Vessels and Nerves of Penis. The dotted lines indicate the saw-cuts required in the alternative dissection mentioned on p. 418.

Changes in Pregnancy.—In the later months of pregnancy, the ligaments of the sacro-iliac and sacro-coccygeal joints and the pubic symphysis become to some extent infiltrated with lymph, which makes them softer and more yielding; the pelvis is thus made more roomy (by slight widening of the symphysis, pushing upwards of the sacrum, and tilting back of the coccyx) during the passage of the head of the child.

Pubic Symphysis.—This is a joint of the secondary cartilaginous type similar to that between two vertebral bodies. The articular surfaces of the pubic bones are coated with hyaline cartilage and united by an interpubic disc of fibro-cartilage supplemented by ligaments which surround the joint.

The *posterior ligament* consists merely of a very thin ribbon of transverse fibres on the pelvic surface of the joint. The *superior ligament* is slightly stronger, and passes across from one pubic crest to the other. The *anterior ligament* is very strong. Its deeper fibres are transverse. The superficial fibres are oblique and cross one another, and mingle with the tendinous fibres of the rectus abdominis and the external oblique aponeurosis. The *inferior ligament* is a strong band shaped like a crescent moon. It rounds off the apex of the pubic arch, and its horns extend for some distance along the inferior rami of the pubic bones. An oval aperture that transmits the deep dorsal vein of the penis (or clitoris) separates it from the transverse ligament of the perineum.

The *interpubic disc* resembles an intervertebral disc ; it is fused with the hyaline cartilage on the articulating surfaces ; and its superficial fibres blend with the ligaments of the joint.

In one respect it differs from an intervertebral disc : a fissure appears in its upper and back part during childhood and becomes a slit-like cavity of variable extent in the adult ; it suggests an approach to the synovial type of joint, but it is not lined with synovial membrane. The cavity is larger in women than in men.

Muscles—Nerves—Vessels

The dissectors will now examine the muscles of the right side of the pelvis. They have partly exposed them already ; and, as they dissect them further, they will trace and clean vessels and nerves.

Dissection.—Define the portion of the *levator ani* attached to the obturator fascia, but do not remove the fascia from either the levator or the obturator internus. Clean the *obturator fascia*, define the margins of the obturator muscle, lift its tendon out of the lesser sciatic notch and examine its deep surface ; and then clean the outer surface of the *obturator membrane*.

Obturator Internus.—The obturator internus is a fairly thick, fan-shaped muscle that clothes nearly the whole of the side wall of the pelvis, from which it has a wide origin. It arises from the obturator membrane, the margins of the obturator foramen and the wide area between the foramen and the greater sciatic notch, where the thick, upper part of the muscle overlaps the notch. The fibres converge upon a tendon which passes through the lesser sciatic foramen, bends at right angles and runs laterally across the back of the hip joint to be inserted into the medial surface of the greater trochanter.

The obturator internus is supplied by a special nerve from the upper part of the sacral plexus (p. 432). It is a lateral rotator of the femur in the erect position, but when the hip joint is flexed it is an abductor.

Obturator Fascia.—The obturator fascia is the most definite layer of fascia in the pelvis. It lines the free surface of the obturator internus. At the margins of the muscle it fuses with the periosteum, except (1) inferiorly where it joins the edge of the falciform process of the sacro-tuberous ligament, and (2) at the anterior (or upper) margin of the obturator foramen, where it passes over the border of the muscle to join the obturator membrane and to form the floor of the *obturator canal*, which transmits the obturator vessels and nerves. It gives origin to nearly the whole of the levator ani. Below the origin of the levator, it is in the side-wall of the ischio-rectal fossa; and, near the falciform process, it splits to form the *pudendal canal* (p. 155).

Dissection.—Find the lower parts of the cut *divisions of the right internal iliac artery*; trace their *branches* and clean them. Strip the *peritoneum* off the pelvic surface of the right part of the sacrum and onwards as far as the root of the pelvic mesocolon. Find the *median sacral vessels*, and trace them downwards to the coccyx, pushing the rectum to the left out of the way; trace the branches of the artery, and look for fine filaments of nerves that twine round it.

Find the right *sympathetic trunk* as it enters the pelvis, and trace it to its end on the coccyx; do so very carefully to avoid injury to its branches, for they are very delicate.

Clean the right *lumbo-sacral trunk* and each of the five *sacral nerves* in turn, noting how they unite to form the *sacral and coccygeal plexuses*. Find the small nerves that spring from the front of the sacral plexus and clean them; trace the plexus to its terminal branches—the *sciatic* and *pudendal*. Then, lift up the plexus, and find and clean the small nerves that spring from the back of it. Next, define and clean the *right piriformis* muscle and the medial part of the divided *coccygeus*, and look carefully for the *coccygeal plexus* of nerves, which lies on the coccygeus near the coccyx.

Lastly, find the medial part of the *levator ani*; clean the

fat and fascia off its pelvic surface, and trace it medially to its insertion, pushing the viscera over to the left side; here again, exercise care, for the posterior part of the muscle is very thin.

Piriformis.—The piriformis lies in the dorsal wall of the pelvis. It arises chiefly from the second, third and fourth pieces of the sacrum, passes laterally and downwards across the lowest part of the sacro-iliac joint, leaves the pelvis through the greater sciatic foramen, enters the gluteal region and runs across the uppermost part of the back of the hip joint, tapering to form a tendon which is inserted into the top of the greater trochanter.

It is supplied by twigs from the anterior primary rami of the first and second sacral nerves. Its actions are the same as those of the obturator internus.

Coccygeus.—The coccygeus will be seen as a whole when the left half of the pelvis is dissected, but, though it is divided on the right side, its position and attachments can be studied. It has been pointed out already that the coccygeus and the sacro-spinous ligament are really one structure. The muscle and ligament lie along the lower border of the piriformis in the dorsal wall of the pelvis where the dorsal wall joins the floor, and are related dorsally to the sacro-tuberous ligament and the gluteus maximus. They spring from the ischial spine and spread out medially to be inserted into the side of the last piece of the sacrum and the first piece of the coccyx. They are supplied by the lower sacral nerves. Owing to the immobility of the insertion, the muscle has little or no action and is therefore undergoing a process of fibrous regression indicated by the presence of the sacro-spinous ligament, which is the degenerated dorsal part of it.

The coccygeus and the levator ani together form a muscular sheet to which the name *pelvic diaphragm* has been given. In lower animals the muscles from which this sheet has been evolved act on the tail. Through the loss of the tail in man, the coccygeus has been degraded to the position of a ligament, while, owing to the assumption of the erect attitude, the muscles from which the levator ani has been derived have altered their insertions and acquired more important functions.

Levator Ani.—The levator ani (Figs. 213, 214, 217, 225, 231) is a wide, thin, curved sheet of muscle—much thinner posteriorly than anteriorly. With its fellow, it forms the muscular floor of the true pelvis, and shuts off the ischio-rectal fossa from the cavity of the true pelvis. It arises from the body of the pubis, the obturator fascia and the ischial spine. From this long, linear origin its fibres curve downwards and medially to be inserted, from before backwards, into the perineal body, the side of the anal canal, the anococcygeal body and the lower three pieces of the coccyx.

The levator ani is a composite muscle derived from muscles which in lower mammals act on the tail. For a full description of the muscle, the names of its component parts and an account of their derivation, the dissectors should consult a Text-book of Anatomy, but they should note now that the best developed portion of it has a special relation to the anal canal.

The more deeply placed anterior fibres are inserted into the perineal body, but many of the fibres that arise from the pubis form a special bundle, known as the *pubo-rectalis* muscle, which sweeps backwards above the other fibres of the levator along the side of the upper part of the anal canal to become continuous with the corresponding fibres of the opposite side. The two pubo-rectales thus form a U-shaped sling around the anal canal at its junction with the rectum; and they are closely associated with the deeper part of the sphincter ani externus.

Nerve-Supply and Actions.—The levator is supplied on its pelvic surface by branches from the anterior primary rami of the coccygeal and lower sacral nerves, and on its perineal surface by branches of the inferior hæmorrhoidal nerve.

The two levatores act together. When they contract they raise the viscera related to them and thus assist the abdominal muscles in compressing the abdominal contents; they are therefore called into use in forced expiration, in vomiting and especially in defæcation; in that act, while the muscle as a whole assists in raising the intra-abdominal pressure, the fibres inserted into the perineal body and anal canal assist also by pulling the canal upwards over the descending mass of fæces. The pubo-rectales muscles have a contrary action; when they contract they pinch in the sides of the gut and pull forwards its posterior wall, increasing the angle between the rectum and anal canal and partly closing the lower end of the rectum; in this way they assist the sphincters in preventing untimely descent of the contents of the rectum into the anal canal.

In the female, the anterior borders of the two levatores act in association with the bulbo-spongiosus muscles as a "sphincter vaginæ"; the whole muscle is of importance also in the mechanism of parturition—supporting the head of the child during the expulsive efforts of the uterus and abdominal muscles. Laceration of the muscle occurs sometimes during childbirth.

Relations.—The *perineal surface* of the levator ani forms the greater part of the medial wall of the ischio-rectal fossa ; and it is covered with a thin fascia that separates it from the

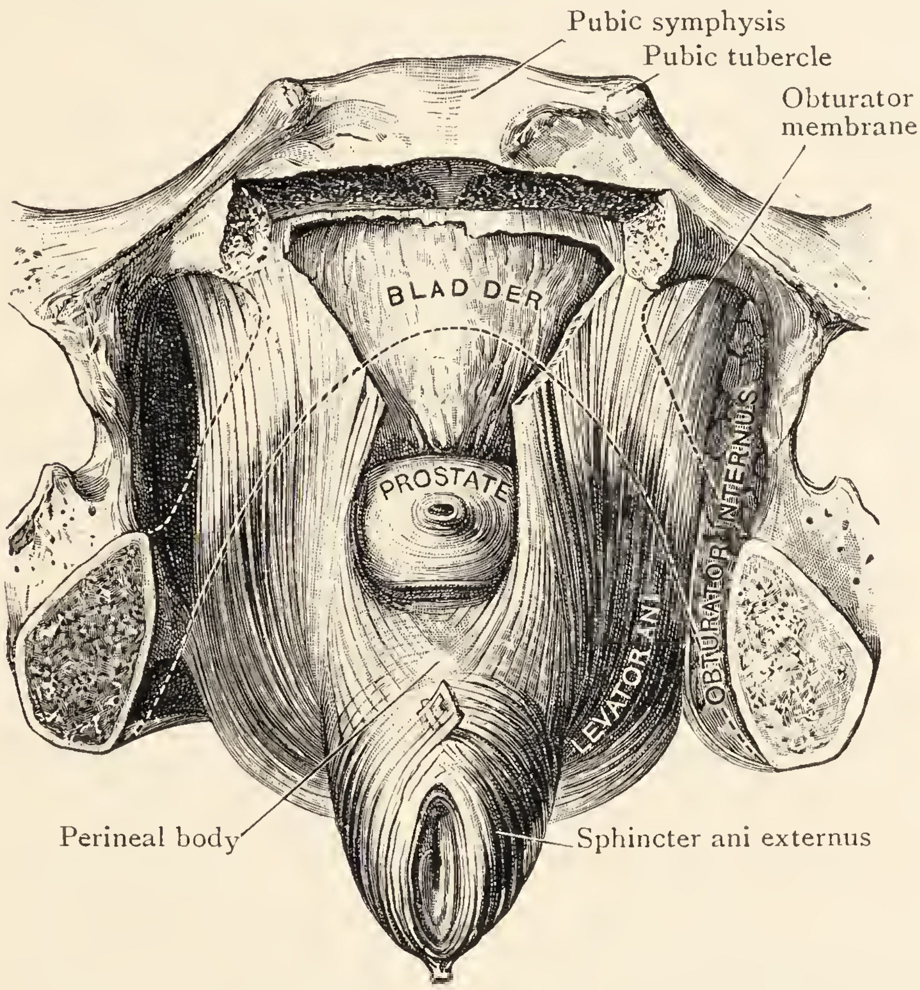

FIG. 214.—Dissection of Levatores Ani in a Male Pelvis.

The pelvis is tilted backwards ; the pubic arch with perineal membrane and structures deep to it, and pubic origins of levatores ani have been taken away. The part of bone removed is shown by dotted lines.

ischio-rectal pad of fat. The *pelvic surface* is related to a number of viscera. **In the male,** it is related to the rectum posteriorly ; the bladder and prostate anteriorly ; the seminal vesicle between the bladder and the rectum ; and the vas deferens and the ureter as they approach the bladder. **In the female,** the rectum is related to it posteriorly, the bladder anteriorly, and the vagina between those two ; the broad ligament is attached to the fat above it, lateral to the vagina ; and the ureter passes forwards below the ligament, close to the vagina.

The *posterior border* of the levator is a thin margin that lies edge to edge with the coccygeus or overlaps it, and the perforating cutaneous nerve sometimes passes out of the pelvis between them. The anterior fibres of the muscle are so oblique that the *anterior border* is "anterior" only in respect that it is the free border of the anterior part of the muscle : it looks medially rather than forwards. It is much the thickest part of the muscle and is separated by a triangular interval from the anterior border of its fellow (Fig. 214).

This interval, **in the male,** is occupied by the lower part of the prostate, which is clasped between the anterior borders of the two levatores (Fig. 214). **In the female,** the vagina passes downwards through the interval ; and the anterior borders of the two levatores, clasping the vagina, form a kind of sphincter for it (Fig. 237).

Nerves that form Sacral and Coccygeal Plexuses.—These nerves have been displayed already ; they are the lumbo-sacral trunk and the anterior primary rami of the five sacral nerves and the coccygeal nerve ; and they should be examined again (Fig. 215).

Lumbo-Sacral Trunk.—The lumbo-sacral trunk is a very thick cord formed of the whole of the anterior primary ramus of the fifth lumbar nerve and the descending part of the fourth (p. 395). It descends obliquely over the ala of the sacrum, enters the pelvis and passes across the pelvic surface of the sacro-iliac joint on to the front of the piriformis.

Sacral and Coccygeal Nerves.—The upper four sacral anterior primary rami emerge from the sacral canal through the anterior sacral foramina. The fifth sacral and the coccygeal, as already explained, descend through the lower end of the sacral canal and enter the pelvis by piercing the ligaments and the coccygeus—the sacral nerve above the transverse process of the coccyx, the coccygeal below it. The first and second sacral are almost as thick as the lumbo-sacral trunk and nearly equal each other in thickness ; the others rapidly diminish in size from above downwards.

They lie on the front of the piriformis and the coccygeus, but the first sacral nerve, before it reaches the front of the piriformis, runs along the upper border of the muscle and crosses the sacro-iliac joint. It should be noted :—(1) that the superior gluteal vessels lie between the first sacral nerve and the lumbo-sacral trunk, and pass backwards out of the pelvis between them ; (2) that the inferior gluteal vessels, at first in front of the nerves, pass downwards and backwards between the first and the second; (3) that the internal pudendal vessels remain in front of the nerves; and (4) that, from the third nerve downwards, the rectum overlaps them and must be pushed over to the left for their complete exposure.

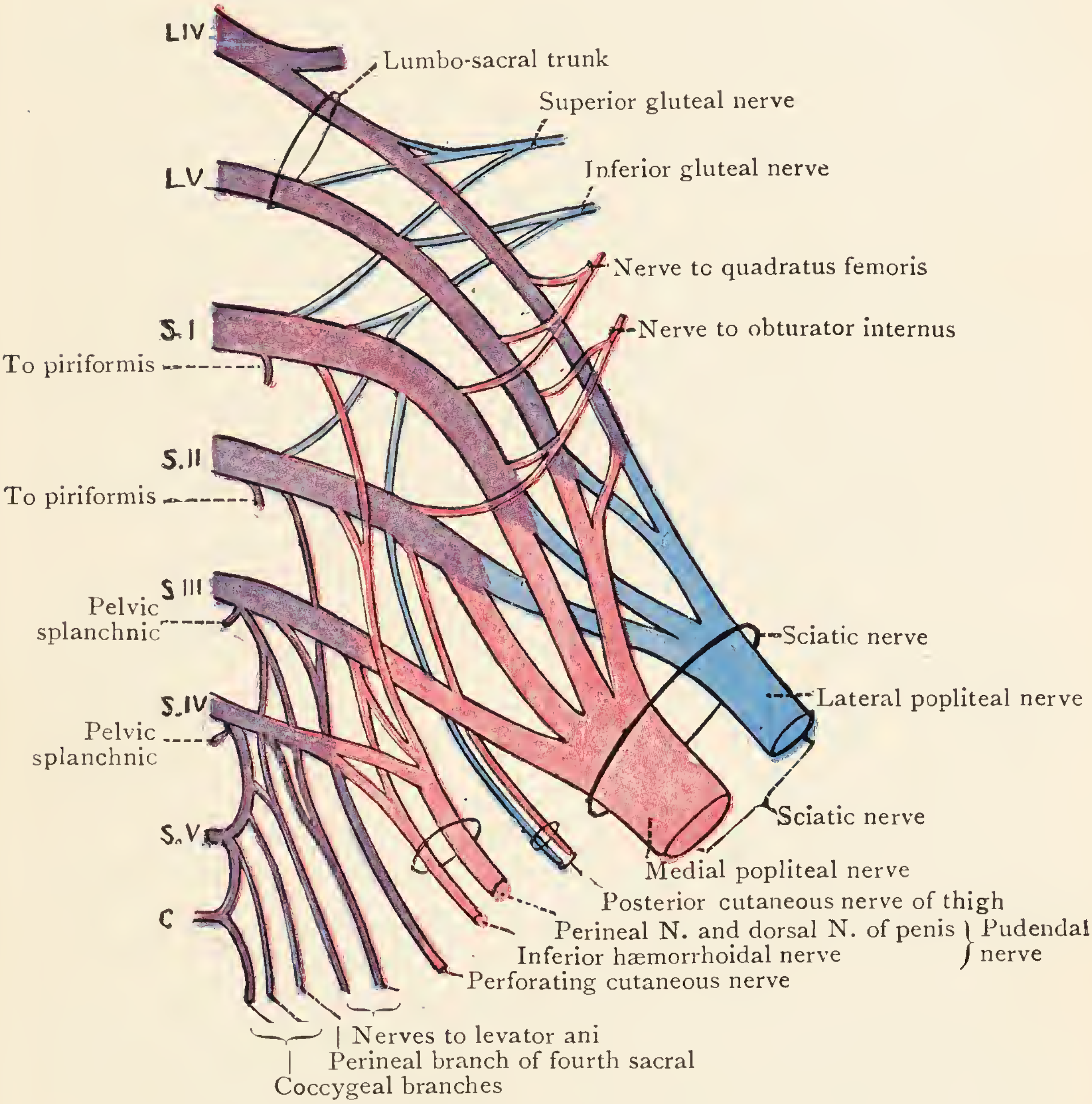

FIG. 215.—Diagram of Sacral and Coccygeal Plexuses.

These nerves unite with one another and with the lumbo-sacral trunk; their angular loops of union and the crossing of the roots of their branches make plexiform arrangements called the sacral and coccygeal plexuses.

Immediately after their entrance into the pelvis, each of them receives a *grey ramus communicans* from the sympathetic trunk; and, before they form the plexuses, certain branches arise from them. These branches are:—(1) twigs from the first and second to the *piriformis* ; (2) irregular branches from the others to the *coccygeus* and *levator ani* ; and (3) the *pelvic splanchnic nerves.*

Pelvic Splanchnic Nerves.—These slender filaments spring from the second and third or the third and fourth sacral nerves. They pass to the pelvic plexuses, in which they form the parasympathetic element (p. 357) ; and they are distributed through these plexuses to the pelvic organs and the lower part of the colon.

Sacral Plexus.—The sacral plexus lies on the pelvic surface of the sacro-iliac joint and of the piriformis, between the muscle and its fascia. It is formed by the lumbo-sacral trunk and the anterior primary rami of the first three sacral nerves and part of the fourth. As the nerve bundles converge upon the lower part of the greater sciatic foramen, they arrange themselves into two terminal nerves—the sciatic and the pudendal, of which the sciatic is the more lateral and very much the larger. The other nerves that arise from the plexus spring from its dorsal and pelvic surfaces.

Terminal Branches of Sacral Plexus.—The **sciatic nerve** is made up of most of the fibres of the lumbo-sacral trunk (fourth and fifth lumbar) and the first three sacral nerves. It is formed on the front of the piriformis, and is at first a wide, flat band ; becoming narrower and thicker, it leaves the pelvis through the lower part of the greater sciatic foramen.

The sciatic nerve ends in the back of the thigh by dividing into two nerves called the lateral and medial popliteal. Sometimes the division takes place in the pelvis, and the lateral popliteal then usually pierces the piriformis as it leaves the pelvis.

The **pudendal nerve** springs by separate roots from the second, third and fourth sacral nerves ; and it passes out of the pelvis between the piriformis and the coccygeus.

Nerves that spring from Pelvic Surface of Sacral Plexus.—These are the nerves to the quadratus femoris and obturator internus.

The **nerve to the quadratus femoris** springs from the lumbo-sacral trunk and the first sacral nerve and derives its fibres from L. 4, 5 and S. 1. Look for it on the pelvic surface of the sciatic nerve, which it accompanies out of the pelvis. The **nerve to the obturator internus** (L. 5 ; S. 1, 2) leaves the pelvis between the sciatic and pudendal nerves.

Nerves that spring from Dorsal Surface of Sacral Plexus.—These form a larger group—superior and inferior gluteal, posterior cutaneous, perforating cutaneous, and the perineal branch of the fourth sacral.

The **superior gluteal nerve** (L. 4, 5; S. 1) arises above the level of the piriformis and passes out of the pelvis through the upper part of the greater sciatic foramen, in company with the superior gluteal vessels.

The **inferior gluteal nerve** (L. 5; S. 1, 2) and the **posterior cutaneous nerve of the thigh** (S. 1, 2, 3) arise to some extent by common roots; they pass out of the pelvis with the sciatic nerve—either behind it or close along its medial side.

The **perforating cutaneous nerve** (S. 2, 3) runs downwards over the piriformis on to the coccygeus, and either threads its way through the lower border of the coccygeus or escapes between the coccygeus and the levator ani to reach the sacro-tuberous ligament below the level of the sacro-spinous ligament; it then bends backwards and perforates the sacro-tuberous ligament and the gluteus maximus to reach the skin of the gluteal region.

The **perineal branch of the fourth sacral nerve** passes downwards from that nerve to the front of the coccygeus, pierces the coccygeus and descends between it and the ligaments to appear in the posterior angle of the ischio-rectal fossa at the side of the coccyx; it then runs onwards over the perineal surface of the levator ani to supply the external sphincter and the skin around the anus.

Coccygeal Plexus.—This plexus is of little importance. It is formed by the anterior primary rami of the coccygeal and fifth sacral nerves and part of the fourth sacral. It lies on the pelvic surface of the coccygeus, gives twigs to the coccygeus and the levator ani, and sends branches backwards through the coccygeus and the ligaments to supply the skin on the back of the coccyx and between the coccyx and the anus.

The students have now to undertake the dissection of the *left* half of the pelvis in order to display the blood-vessels, the sympathetic nerves, the obturator nerve, and the ureter; and also *in the male* the vas deferens, *in the female* the round ligament of the uterus. The dissectors of a *female* pelvis will try to keep the broad ligament intact as they clean the various structures.

Dissection.—Stitch the left *ureter* and the left *vas deferens* (or *round ligament of the uterus*) to the beginning and the end of the external iliac artery to prevent their displacement. **In the**

female, cut carefully through the peritoneum on both sides of the *root of the broad ligament*. Then, **in both male and female,** strip off the *peritoneum* (using the knife when necessary) from the brim as far as the root of the pelvic mesocolon, the side of the rectum and the lateral border of the bladder.

Identify the *levator ani* in the perineum, and pass the finger over it up to its origin ; then, gauge its position from the pelvic side, and in the following dissection avoid injury to it or to the fascia that covers its pelvic surface.

Clean first the *vas deferens* as far as the bladder, and then the *ureter*. Or, **in the female,** clean first the *round ligament* as far as the broad ligament, and then the *ureter* as far as the bladder—avoiding injury to the broad ligament.

Now, find the *obturator nerve* as it escapes from the psoas, and trace it to its exit from the pelvis. Next, clean the trunks of the *internal iliac artery* and *vein* ; endeavour to preserve some of the sympathetic nerve filaments that surround the artery and its branches, and look for *lymph-glands* that lie alongside them. Trace the branches of the artery to their exit from the pelvis and to the viscera they supply. Clean and preserve the obturator vein, but remove the veins that accompany the other branches, if they are in the way. Remember that the obturator artery or the vein (or both) may be replaced by an *abnormal obturator vessel* from the inferior epigastric.

Find the *sympathetic trunk* as it enters the pelvis, and trace it downwards. Secure the *rami communicantes* which it sends to the anterior primary rami of the sacral nerves. To trace the lower part of the trunk, push the rectum aside, and look for twigs that the trunk gives to the rectum.

Find the *superior rectal vessels* again, and trace them to the rectum. Finally, trace the *lumbo-sacral trunk* and the *upper two sacral nerves* to their junction with one another.

Median Sacral Artery (Fig. 191).—This small artery was originally the caudal part of the aorta. It springs from the back of the aorta immediately above its bifurcation, runs downwards over the lower two lumbar vertebræ behind the left common iliac vein, crosses the sacral promontory and proceeds over the pelvic surface of the sacrum under cover of first the peritoneum and next the rectum, and ends on the coccyx in a small fibro-cellular body of unknown function called the *glomus coccygeum*. The branches are :—(1) the fifth pair of lumbar arteries, (2) small branches that anastomose with the lateral sacral arteries, and (3) twigs to the back of the rectum.

Its *venæ comitantes* unite to form a single vein which runs usually along its right side and ends in the left common iliac.

Superior Rectal Artery (A. Hæmorrhoidalis Superior).—This is the continuation of the inferior mesenteric artery. It begins on the middle of the left common iliac artery, enters the root of the medial limb of the pelvic mesocolon, and descends in it to the third piece of the sacrum, where it divides into two diverging branches that run downwards, first on the back of the rectum and then on its sides. These branches soon divide into smaller branches which range themselves round the gut, pierce the muscular coat about its middle, and descend in the submucous coat to the anal canal.

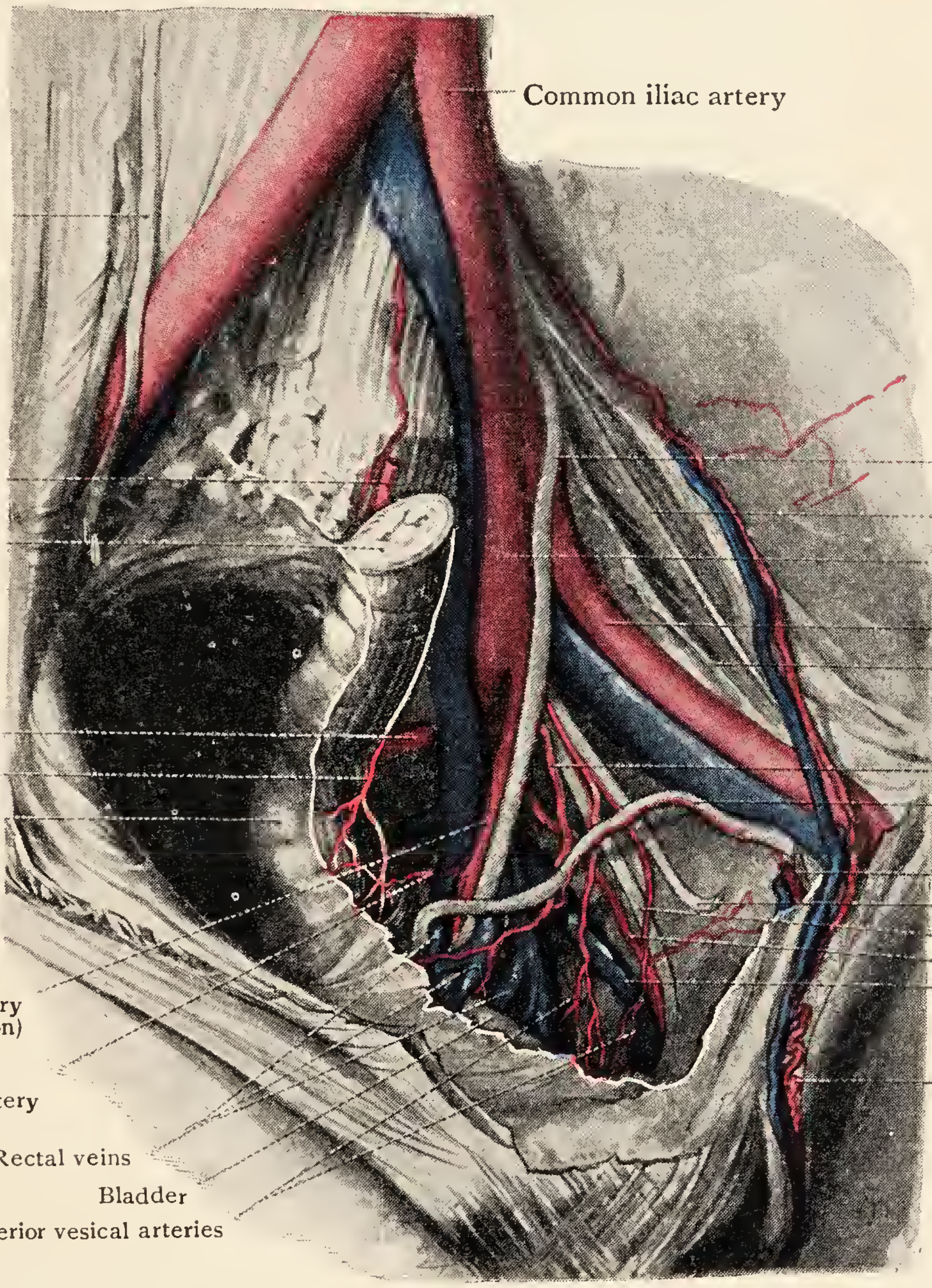

FIG. 216.—Structures exposed in left half of a Male Pelvis by removal of peritoneum and extraperitoneal fat.

The *superior rectal vein* accompanies the artery and becomes the inferior mesenteric.

Internal Iliac Artery (A. Hypogastrica) (Figs. 216, 217).—The internal iliac is by far the largest artery in the true pelvis, and gives rise to all the arteries of the pelvis except the median sacral and superior rectal (and the ovarian, in the female). It is the smaller of the two branches of the common iliac, but is a wide vessel about an inch and a half long. It begins on the medial margin of the psoas major, opposite the sacro-iliac joint at the level of the lumbo-sacral disc, and passes

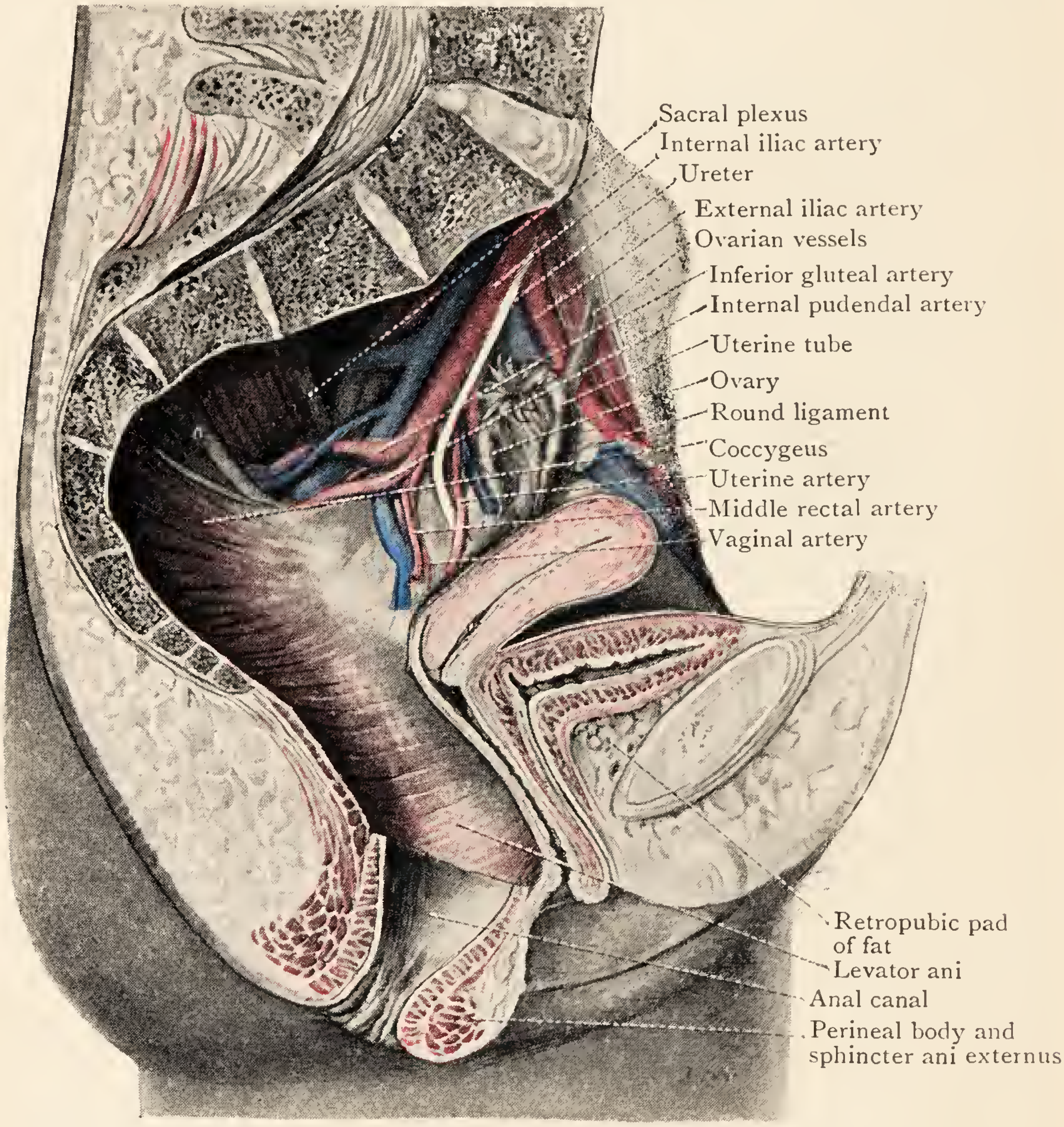

FIG. 217.—Dissection of a Female Pelvis, showing Muscles on dorsal wall and floor and the Structures on side wall above Broad Ligament.

backwards and slightly downwards across the medial surface of the psoas into the pelvis to end near the upper margin of the greater sciatic foramen by splitting into two divisions—an anterior and a posterior.

Relations.—Its relations are very simple. Its own vein is above and behind it; the ureter is below and in front; peritoneum clothes its medial surface and separates it from the intestines ; laterally, it is separated from the psoas by the external iliac vein, and from the bony wall of the pelvis by the obturator nerve.

Condition in the Fœtus.—In the fœtus, the **internal iliac artery** is twice as wide as the external iliac. It gives off branches near the sciatic foramen, but, instead of ending there, it is continued forwards as the umbilical artery. The fœtal *umbilical artery* runs in the extraperitoneal tissue of the ventral wall of the abdomen to the umbilicus, through which it passes in company with its fellow and the umbilical vein. Outside the abdomen, the arteries enter the umbilical cord at once, and, twining spirally round the umbilical vein, they pass to the placenta, where their blood is brought into relation with the maternal blood. At birth, the umbilical cord is ligatured and divided ; the umbilical arteries begin immediately to undergo atrophy ; they retain a narrow lumen until they pass the bladder, but beyond that the lumen is obliterated soon after birth, and they are then named the *lateral umbilical ligaments*.

Branches of Internal Iliac Artery.—The posterior division gives off the *ilio-lumbar* artery and two *lateral sacral* arteries, and is then continued onwards as the *superior gluteal* artery. The anterior division gives off the *umbilical*, the *obturator*, the *inferior vesical* and the *middle rectal*, and then divides into the *inferior gluteal* and *internal pudendal*. **In the female,** the *uterine* is an additional branch of the anterior division, and the *vaginal* replaces the inferior vesical of the male.

This is the common method of branching, but it should be noted that variation is very common, especially among the branches of the anterior division. It is usual to classify them in two groups—parietal and visceral.

Posterior Division	Anterior Division		
Parietal	Parietal	Visceral	
		Male	Female
Ilio-lumbar Lateral sacral Superior gluteal	Obturator Internal pudendal Inferior gluteal	Umbilical Superior vesical Middle rectal Inferior vesical	Umbilical Superior vesical Middle rectal Vaginal Uterine

Ilio-Lumbar Artery.—This artery springs from the beginning of the posterior division or from the end of the internal iliac trunk. It passes upwards between the obturator nerve and the lumbo-sacral trunk and disappears behind the psoas, where it divides into two branches. The *iliac branch* passes laterally behind the psoas and ramifies in the iliac fossa; some of its branches have been seen already on the surface of the iliacus. The *lumbar branch* is smaller; it runs upwards behind the psoas to end in the quadratus lumborum.

The *ilio-lumbar vein* does not descend into the pelvis; it ends in the back of the common iliac vein.

Lateral Sacral Arteries.—These are two arteries of narrow calibre that run medially and downwards in front of the sacral nerves, and each of them divides into two. Four arteries are thus formed, and they pass through the anterior sacral foramina to supply the structures in the sacral canal, whence their terminal branches emerge through the posterior sacral foramina and sink into the muscles on the back of the sacrum to supply them and the overlying skin.

Superior Gluteal Artery.—This large artery is the continuation of the posterior division and is much the widest branch of the internal iliac. Its course in the pelvis is short. It is first in the fat above the greater sciatic foramen; it then pierces the fascia of the pelvis and runs backwards between the lumbo-sacral trunk and the first sacral nerve, across the pelvic surface of the sacro-iliac joint, and passes out of the pelvis into the gluteal region, above the piriformis muscle, through the uppermost part of the greater sciatic foramen.

Umbilical Artery.—The umbilical artery springs from the upper end of the anterior division or the lower end of the iliac trunk. It runs downwards and forwards along the side wall of the pelvis in front of and above the obturator nerve, parallel to the side of the bladder—some distance from it when it is empty, but in contact when it is full. As the artery passes the bladder it gives two or three *superior vesical arteries* to the upper part of that viscus. As far as the origin of these arteries it has a small lumen for the conveyance of blood to them. Beyond them, it loses its lumen and is called the *lateral umbilical ligament*; and, under that name, it passes out of the pelvis and ascends in the extraperitoneal tissue of the anterior abdominal wall to the umbilicus.

The umbilical artery has no companion vein, for the *umbilical vein*, which accompanies the fœtal arteries in the umbilical cord, leaves them at the umbilicus and passes to the liver; after birth it becomes the *round ligament of the liver*.

Obturator Artery.—The obturator artery arises close to the umbilical artery. It runs downwards and forwards along the side wall of the pelvis, and leaves the pelvis through the anterior part of the obturator foramen to enter the thigh. In the pelvis, it is behind and below the obturator nerve, between the nerve and its vein ; it gives small twigs to neighbouring structures, including a *pubic branch*, which anastomoses on the pelvic surface of the pubis with the pubic branch of the inferior epigastric. The pubic branch acquires importance when it enlarges to form a part of the abnormal obturator artery.

Abnormal Obturator Artery.—This artery is an enlarged form of the pubic branches of the obturator and inferior epigastric arteries ; and it is present in nearly 30 per cent. of bodies. It springs from the inferior epigastric, descends behind the inguinal ligament, passes either medial or lateral to the femoral ring (p. 241), and crosses the pubic bone to reach the obturator foramen. It replaces the obturator artery wholly or in part. It may be present on one or both sides and may or may not be accompanied by an *abnormal obturator vein* ; or the abnormal vein may be present though the artery is normal.

Inferior Vesical Artery.—This small artery is peculiar to the male. It arises a little below the obturator artery, and runs forwards in the fat, below the peritoneum, to the bladder. Its branches supply the seminal vesicle, the prostate, and the posterior and inferior parts of the bladder ; and it gives off a long slender branch—the *artery of the vas deferens*—which supplies the vas and accompanies it as far as the testis.

In the female the **vaginal artery** takes the place of the inferior vesical of the male, and is larger. It arises a little below the obturator artery and descends in the fat towards the bladder, dividing into branches most of which are intercepted by the vagina, while others pass onwards to the posterior and lower parts of the bladder.

Uterine Artery (Fig. 217).—The uterine artery is a large artery that arises near the lower end of the anterior division of the internal iliac or may arise in common with the vaginal, umbilical or middle rectal. It descends in the fat to the root of the broad ligament, insinuates itself between the two layers of the ligament, and passes medially above the ureter and the upper end of the side of the vagina to reach the uterus. It then runs tortuously along the side of the uterus, and its terminal part, after giving twigs to the uterine tube, ends by anastomosing with a branch of the ovarian artery. Its branches supply the vagina, the uterus and the tube.

Middle Rectal Artery (A. Hæmorrhoidalis Media).—This is a small artery that arises near the lower end of the anterior division. It runs medially to the rectum, ramifies in its walls, and sends twigs forwards to the vagina or to the seminal vesicle and the prostate. A condensation of the extraperitoneal areolar tissue around the artery assists in holding the rectum in place.

Internal Pudendal Artery.—This artery is one of the terminal branches of the anterior division. It runs downwards and backwards in the fat in front of the sacral plexus and the piriformis, pierces the pelvic fascia and leaves the pelvis through the lower part of the greater sciatic foramen to enter the gluteal region below the piriformis ; it then descends across the back of the tip of the ischial spine and passes through the lesser sciatic foramen into the perineum, where it has been dissected already.

In the pelvis, it gives off only small twigs to the fat and to the piriformis. Its branches in the perineum have been described already (pp. 157, 169, 176) ; one of them is the *inferior rectal artery*, which supplies the anal canal and the lower part of the rectum.

Inferior Gluteal Artery.—This is the other terminal branch of the anterior division and is its largest branch. It is usually behind and lateral to the pudendal artery. It descends in the fat in front of the first sacral nerve and the piriformis, pierces the fascia, and, after passing between the first and second sacral nerves (or second and third), it leaves the pelvis through the lower part of the greater sciatic foramen to appear in the gluteal region below the piriformis at the medial side of the sciatic nerve or on the back of the nerve. Its branches in the pelvis are mere twigs to neighbouring structures.

Hernia through Pelvic Wall.—It has been explained that the arteries which leave the pelvis pierce the fascia in order to do so. An exception to that rule is the *obturator artery*, which passes over the anterior border of the obturator fascia as it enters the obturator canal. The relation of these blood-vessels to the lining fascia is of some practical importance, for a portion of gut may make its way through one of the openings for the arteries and form a hernia. A **gluteal hernia** may pass through the greater sciatic foramen above the piriformis with the superior gluteal artery ; similarly, a hernia may pass below the piriformis with the inferior gluteal artery, and, from its proximity to the sciatic nerve, is termed a **sciatic hernia.** In an **obturator hernia,** the gut follows the obturator artery over the fascia into the obturator canal.

Veins of Pelvis (Figs. 216, 217).—The chief veins of the pelvis are the two internal iliac veins and their tributaries ; but, besides these, there are the superior rectal (p. 435), the median sacral (p. 434), and (in the female) a pair of ovarian pampiniform plexuses (p. 380).

Internal Iliac Vein.—This is the widest vein in the pelvis. It is a short, wide vessel formed by the confluence of the venæ comitantes of the superior gluteal artery and most of the veins that accompany the other branches of the internal iliac artery. It begins immediately above the greater sciatic foramen and passes forwards and slightly upwards out of the pelvis to end on the medial surface of the psoas by joining the external iliac vein to form the common iliac. Its own artery is below and in front of it ; the sacro-iliac joint and the lumbo-sacral trunk are above and behind it ; medially, it is separated from the intestines by the peritoneum ; laterally, it is related first to the pelvic wall and the obturator nerve, and then to the psoas.

Tributaries.—The tributaries are the single *obturator vein*, irregular *middle rectal veins* and the *venæ comitantes of the gluteal*, *internal pudendal* and *inferior vesical* (or *vaginal*) arteries. By far the largest of them are the veins that accompany the superior gluteal artery—which is the biggest branch of the internal iliac. These tributaries do not correspond to all the branches of the artery, for, as explained already, the umbilical artery has no companion vein, and the ilio-lumbar vein ends in the common iliac.

Plexuses of Veins.—The veins of the pelvis are thin-walled ; they not only accompany the arteries but also anastomose freely, forming venous networks in the pelvic fat ; and there are dense plexuses on and in the walls of the viscera from which the visceral veins spring. These plexuses are named *rectal*, *vesical*, *prostatic*, *uterine* and *vaginal* ; but they are not closed systems : owing to the freedom of the anastomoses, the plexuses of one organ communicate with the plexuses of its neighbours.

The students will endeavour to dissect the plexuses when cleaning the viscera, but a satisfactory display can seldom be made unless the veins have been specially injected.

The **rectal venous plexuses** lie in the submucous coat of the rectum and anal canal and on their surfaces, and they are drained by three sets of veins—*superior*, *middle* and *inferior rectal*. The superior rectal is a part of the portal system; the middle and inferior rectal are systemic veins. The plexuses therefore form a link between portal and systemic veins (Fig. 168). This is of practical importance in association with the production of *hæmorrhoids* or *piles*, which are due to a varicose condition of the veins of the anal canal. Though the smaller veins of the portal system are provided with valves, the portal vein itself and its large tributaries are without them; consequently, anything which retards the flow of blood through the portal system will react on the rectal plexuses, cause distension of their veins and predispose to the formation of piles.

Owing to the freedom of anastomoses mentioned already, the veins of the portal system in the rectum communicate indirectly with the systemic veins in neighbouring organs; and stress has recently been laid on the clinical importance of the communications between the rectal and uterine veins in conditions of portal obstruction (E. G. Wermuth).

The **vesical venous plexus** *in the male* lies on the surfaces of the bladder (chiefly below and behind), and around the seminal vesicles, the terminal parts of the vasa deferentia and the vesical ends of the ureters. The plexus is drained into the internal iliac vein by large *vesical veins* that accompany the inferior vesical artery.

The **prostatic venous plexus** (Fig. 218) is a dense network that lies on the front and sides of the prostate, between its capsule and its fascial sheath. Anteriorly, it receives the *deep dorsal vein* of the penis; superiorly, it is continuous with the vesical plexus, into which its blood is drained.

The **vesical venous plexus** *in the female* lies on the surfaces of the bladder, and is densest around the neck and the upper part of the urethra, where it receives the *dorsal vein* of the clitoris. It is drained into the vaginal plexuses.

The **vaginal venous plexuses** are massed on the sides of the vagina. They communicate with the vesical, rectal and uterine plexuses; a *vaginal vein* arises from the upper part on each side and runs along the vaginal artery to the internal iliac vein.

The **uterine venous plexuses,** like the vaginal, are chiefly on the sides of the organ, and they surround the uterine arteries. The *uterine veins* arise in the lower part of the plexus, on each side, and accompany the proximal part of the artery to the internal iliac vein. Veins that run along the uterine tube connect the uterine and ovarian plexuses.

Lymph-Glands and Lymph-Vessels of Pelvis (Figs. 194 and 219).—The lymph-glands are usually obscured by the pelvic fat, but some of them will have been found if the subject is thin, especially if they have been enlarged by disease. They are arranged in three main groups—external iliac, internal iliac and sacral.

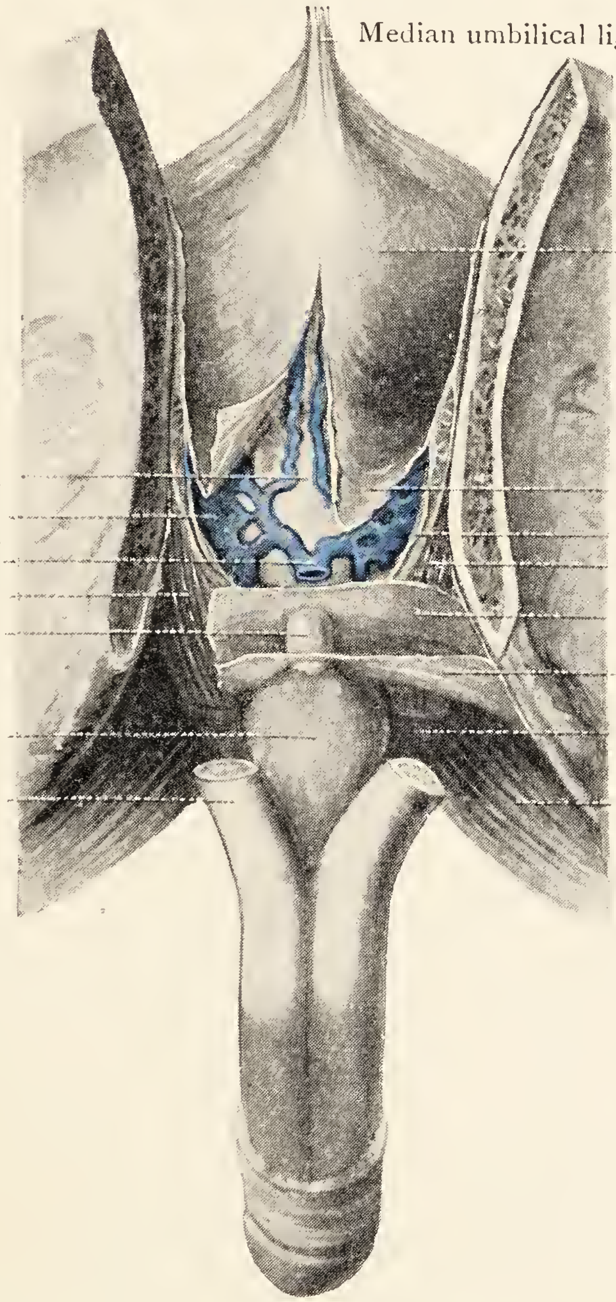

FIG. 218.—Dissection of Bladder and Prostate from the front, showing Prostatic Plexus of Veins. (For further stage of this dissection *see* Fig. 231.)

The *external iliac glands* are described with the glands of the abdomen proper (p. 385), but they must be included among the glands of the pelvis also because they receive lymph-vessels directly from the bladder, the prostate and the neck of the uterus.

The *internal iliac glands* lie in relation to the internal iliac vessels. Lymph-vessels that accompany the gluteal and internal pudendal vessels convey lymph to them from the deep parts of the gluteal region and perineum ; and they receive the lymph from all the pelvic viscera except the ovary and

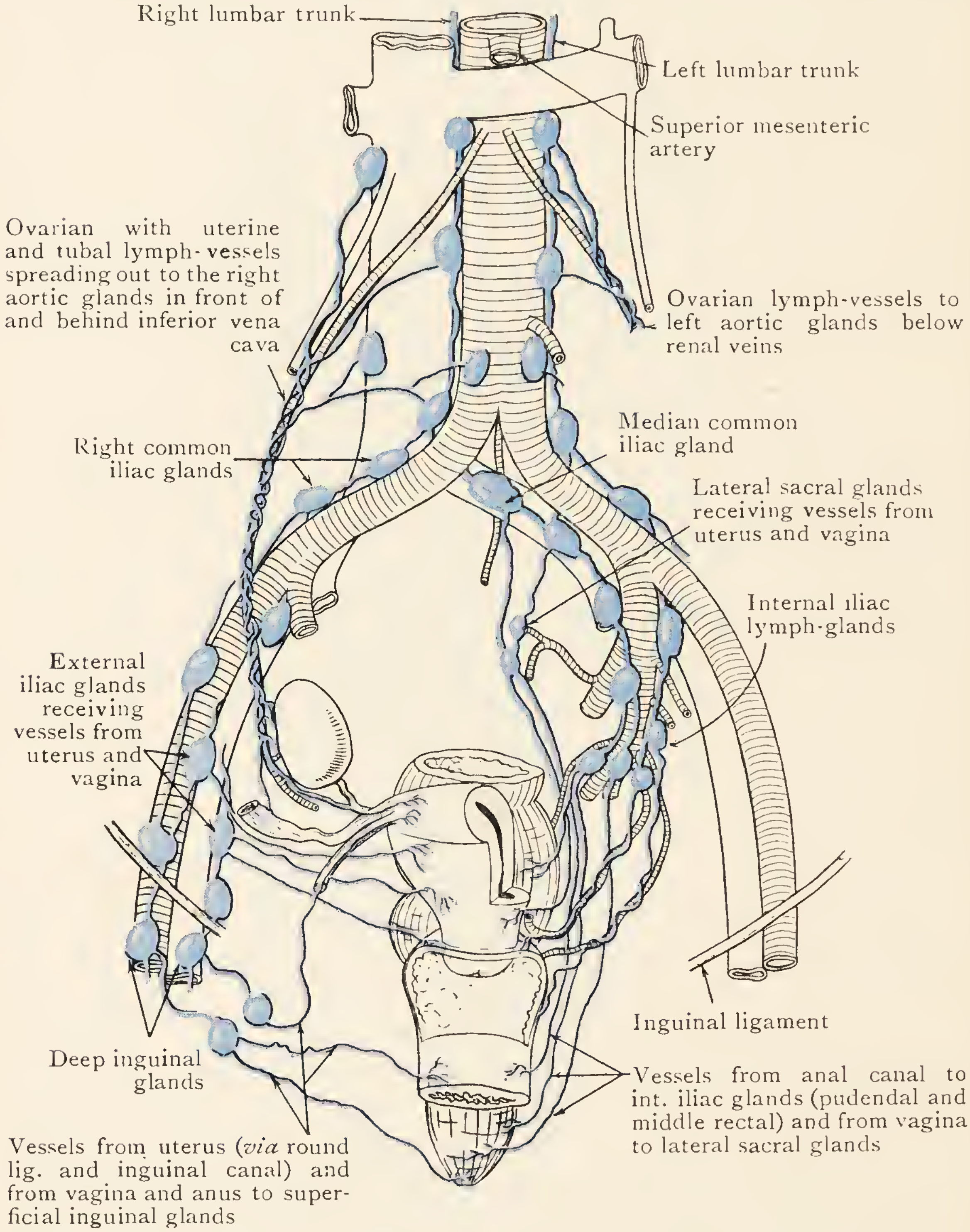

FIG. 219.—Diagram of Lymph-Vessels and Lymph-Glands of Female Pelvis and Abdomen. Cf. Fig. 194, p. 386 (male), in which other details common to the sexes will be found.

the uterine tube. Their efferent vessels pass to the common iliac glands (p. 385).

The *sacral glands* are :—(1) one or two glands placed on the course of the median sacral artery, and (2) a pair of chains placed in relation to the anterior sacral foramina on the branches of the lateral sacral arteries. They receive lymph from the dorsal wall of the pelvis; but their more important afferents convey lymph from the rectum, the neck of the bladder, the neck of the uterus or the prostate. Their efferents pass to the common iliac glands.

Besides these main groups, there are small glands that lie in the fascial sheaths of the bladder and the rectum, and in the broad ligament of the uterus. They are placed on the course of lymph-vessels from those organs and acquire importance when these organs are the seat of malignant tumours.

Obturator Nerve (Fig. 216).—This is the only spinal nerve that runs its pelvic course in the extraperitoneal fat. It arises in the substance of the psoas from the anterior primary rami of the second, third and fourth lumbar nerves. It emerges through the medial side of the psoas at the posterior part of the pelvic brim, pierces the fascia and passes into the true pelvis. It runs downwards and forwards along the side wall of the pelvis, and escapes into the thigh through the anterior part of the obturator foramen. During its descent through the pelvis, it is closely applied to the side wall at the edge of the obturator internus muscle, and is in front of the obturator vessels. The umbilical artery first crosses it and then runs downwards in front of it. It is crossed also :—(1) near its entrance into the pelvis by the internal iliac vessels and the ureter; (2) lower down *in the female* by the attachment of the broad ligament; and (3) near its exit by the round ligament of the uterus or by the vas deferens.

Sympathetic and Parasympathetic Nerves in Pelvis.—The parts of the sympathetic nervous system that are found in the true pelvis are :—(1) the pelvic parts of the two *sympathetic trunks* and their branches, and (2) the *pelvic plexuses* and their offshoots. The parasympathetic system is represented by *pelvic splanchnic nerves* (pp. 432, 447).

Sympathetic Trunk.—The pelvic portion of each sympathetic trunk enters the pelvis by crossing the margin of the ala of the sacrum. It proceeds over the pelvic surface of the sacrum, crossing the medial parts of the anterior sacral foramina, and it ends on the coccyx by joining its fellow in a median ganglion called the *ganglion impar*. (*Impar*, like *azygos*, means unpaired.) Its upper part is under cover of the peritoneum, which separates it from the ileum or the pelvic colon ; its lower part is behind the rectum.

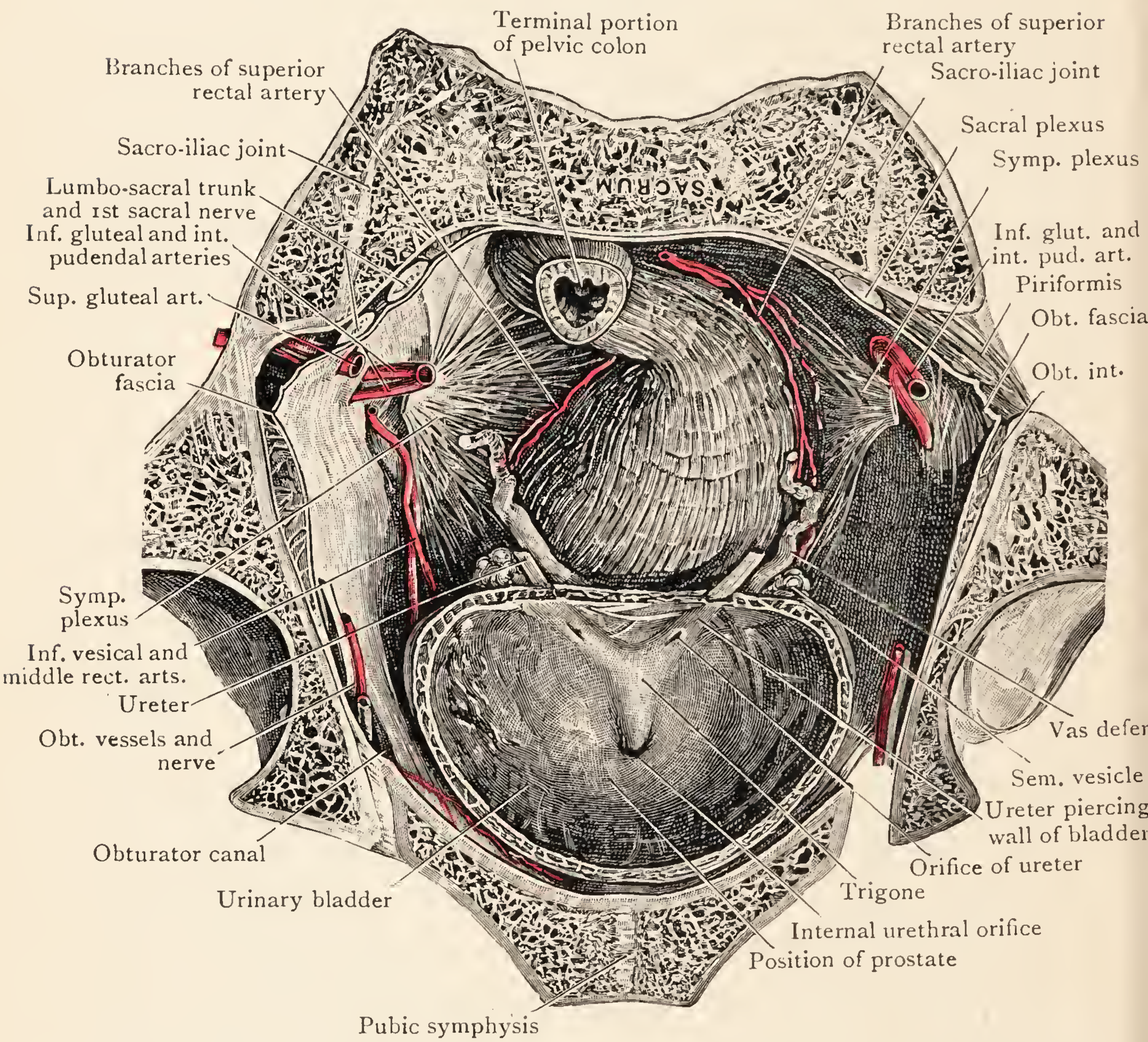

FIG. 220.—Oblique Section from above downwards and forwards through Pelvis. The peritoneum and extraperitoneal tissue have been removed.

Ganglia.—There are four *ganglia* on the trunk—one at each sacral foramen—and the ganglion impar; and the branches of the trunk spring from them.

Branches.—They are :—(1) grey rami communicantes to the anterior primary rami of the sacral and coccygeal nerves ; (2) small filaments which form a plexus around the median sacral artery; (3) branches from the upper ganglia to the pelvic plexuses; (4) branches from the lower ganglia to the rectum; and (5) twigs from the ganglion impar to the glomus coccygeum.

Pelvic Plexuses.—It has been explained already that the hypogastric plexus divides to form a pair of pelvic plexuses. Each pelvic plexus inclines laterally to reach the internal iliac artery. It surrounds the artery with an interlacement of fine nerves which is joined by branches from the upper sacral ganglia of the sympathetic trunk; and it divides into secondary plexuses which accompany the branches of the artery—the largest offshoots being those that accompany the visceral arteries (surrounding them and also lying in the fat between them); and these offshoots are joined by the branches of the pelvic splanchnic nerves. Minute *ganglia* may be found at the points where the branches from the sympathetic trunk join the plexuses.

Visceral Plexuses.—When the vessels reach their destination, these plexiform nerves form networks on the viscera, and the networks give rise to the terminal branches. Thus, there are:—(1) a *rectal plexus*, to which the inferior mesenteric plexus sends a contribution along the superior rectal artery; (2) a *vesical plexus* and a *plexus of the vas deferens*, associated with the bladder, vas deferens and seminal vesicle; (3) a *prostatic plexus*, which sends *cavernous nerves* (greater and lesser) down along the membranous part of the urethra to the penis; and (4) *uterine* and *vaginal plexuses*, which accompany the uterine and vaginal arteries. The vaginal plexus supplies the urethra as well as the vagina—and also the bulbs of the vestibule and the clitoris.

The plexuses supply the organs with both sympathetic and parasympathetic fibres—and these two sets of fibres have antagonistic functional effects.

The exact paths pursued by some of these fibres have recently become of surgical importance. For example, the sympathetic nerve-fibres for the bladder arise from the upper lumbar ganglia of the sympathetic trunks and reach the pelvis *via* the hypogastric plexus (which is the "presacral nerve" of the surgeons). Section of this path ("presacral neurectomy") is now performed for certain conditions in which there is difficulty in emptying the bladder (Learmonth); and, since sympathetic nerves contain afferent as well as efferent fibres, it is divided (with other nerve connexions) for the relief of pain in inoperable cancer.

Pelvic Viscera

The pelvic part of the ureter in the female *is described below.*

Pelvic Part of Ureter in the Male (Figs. 206, 216).—The ureter crosses the origin of the external iliac artery, passes backwards and downwards along the lower border of the internal iliac artery and reaches the level of the ischial spine; it then curves forwards and medially in the fat above the levator ani to reach the postero-superior angle of the bladder. It pierces the posterior wall of the bladder very obliquely—medially and downwards—and opens into it at the upper angle of an area called the trigone of the bladder (p. 469).

Relations.—Until the ureter approaches the bladder, it is immediately under cover of closely-adherent peritoneum, and can be seen shining through it. In the first part of its course, the internal iliac artery is above and behind it; the peritoneum clothes it medially and below; lateral to it, there are, in succession from before backwards, the external iliac vein, the psoas, the obturator nerve, the umbilical artery, the obturator vessels and the inferior vesical vessels; but the obturator vein and the inferior vesical vessels may cross its medial side. In the second part of its course, its relations are more simple: peritoneum clothes it, and the fat separates it from the levator ani beneath; but, near the bladder, it is surrounded by a plexus of veins, is crossed by the vas deferens, and is overlapped by the upper end of the seminal vesicle.

The dissectors of the male pelvis *will now pass to the dissection of the vas deferens on p.* 453.

Pelvic Part of Ureter in the Female (Figs. 209, 217, 221, 237). The ureter crosses the origin of the external iliac artery and runs backwards and slightly downwards into the pelvis closely applied to the lower (or anterior) border of the internal iliac artery. Near the base of the ischial spine it curves forwards and medially in the fat of the pelvic floor, passes below the root of the broad ligament, and reaches the bladder at its postero-superior angle. It pierces the posterior wall of the bladder obliquely in a medial direction and downwards, and opens into it at the upper corner of an area called the trigone of the bladder (p. 469). Until it reaches the broad ligament it is adherent to the overlying peritoneum and can be seen shining through it.

Relations.—In an operation in the interior of the pelvis, the position of the ureter has to be kept constantly in mind. For, if the ureter is cut, it does not give evidence of the injury

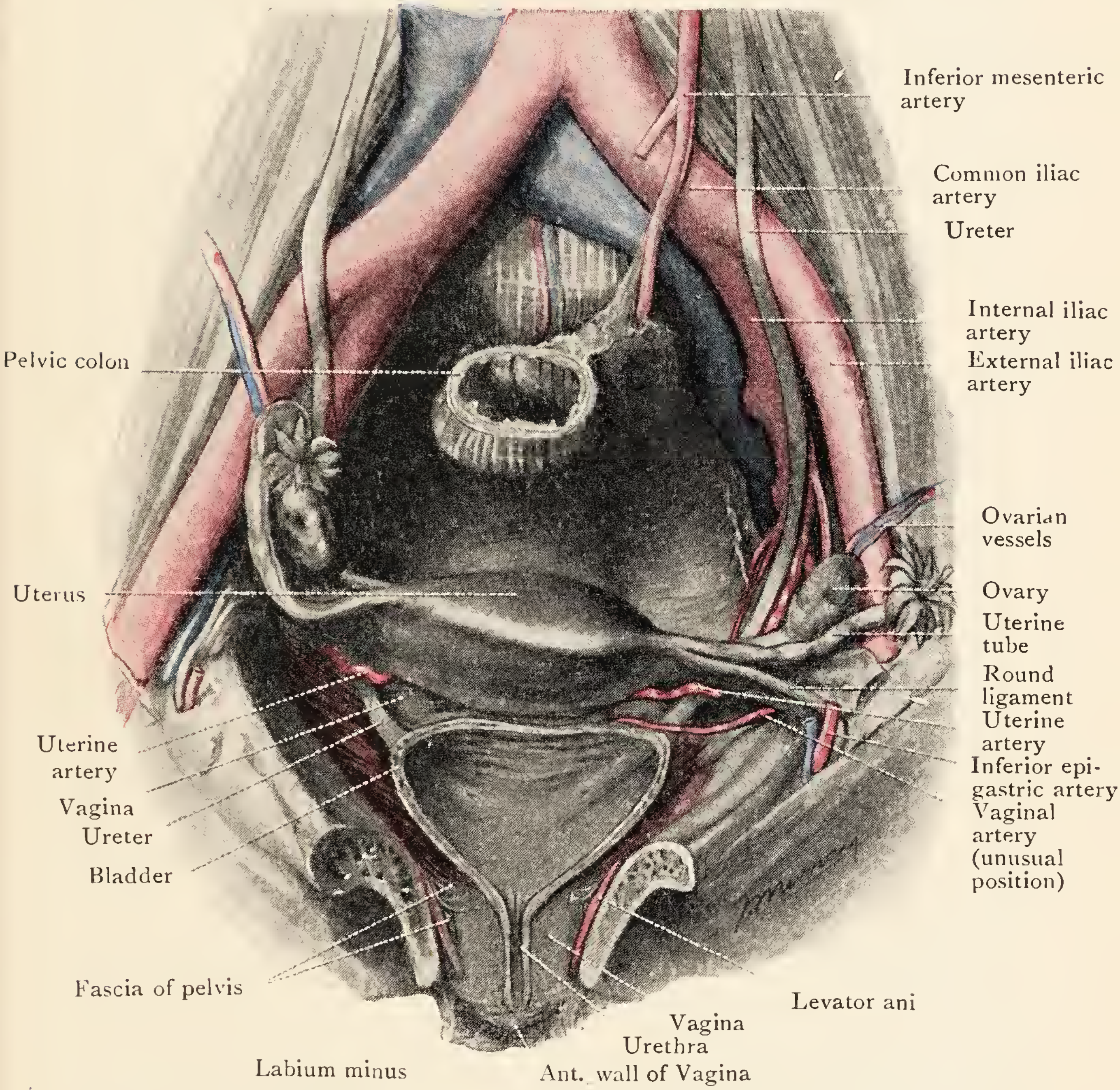

FIG. 221.—Dissection of Pelvis of a multiparous female, showing the relations of Bladder to Uterus and Vagina, of Vagina to Urethra and Broad Ligaments, and of Ureters to Broad Ligaments and Vagina.

like a blood-vessel. Even if the injury is discovered, to mend the ureter is difficult or may be impossible, and no other structure can take its place. It is therefore important that the relations of the ureter should be studied very carefully.

In the first part of its course, the internal iliac artery is above and behind it ; the peritoneum clothes it medially and also inferiorly (in front)—separating it from the ovary. On its lateral side there are, in succession, the external iliac vein, the psoas, the obturator nerve, the umbilical artery, the obturator, vaginal and uterine vessels ; but the obturator vein and the vaginal and uterine vessels may cross its medial side.

In the second part of its course, it passes below the broad ligament, and the uterine vessels cross above it ; it lies first in the fat above the levator ani, and next on the upper end of the side of the vagina ; and it usually has to pass for a short distance obliquely in front of the vagina to reach the bladder. Its intimate relation to the vagina should be specially noted (Figs. 221 and 237). While one forefinger traces the ureter, pass the other forefinger into the vagina and verify the relationship. As the upper end of the vagina commonly deviates a little to the left side in conformity with the asymmetrical position of the uterus (p. 481), the left ureter is usually more intimately related to the vagina than the right ; it is therefore in greater danger during operations and is more often damaged by pressure during parturition.

Examine the round ligament of the uterus, the ovary and its ligament before any further dissection is made.

Ligamentum Teres Uteri (Figs. 209, 221, 222).—The **round ligament of the uterus** is a long slender band of non-striped muscle mixed with fibrous tissue. It is attached to the vesical surface of the uterus close to the uterine tube. From that point, it passes to the side wall of the pelvis in the broad ligament; it raises a ridge on the lower surface of the broad ligament, or it may be contained in a prominent fold of the lower layer of the ligament. At the side wall of the pelvis, it leaves the broad ligament and passes towards the deep inguinal ring. In that part of its course, it is immediately underneath the peritoneum and can be seen through it ; and it crosses the obturator vessels and nerve, the umbilical artery and the external iliac vein. Immediately before it enters the ring, it lies on the external iliac artery behind the root of the inferior epigastric artery, and it curves round the lateral side of the epigastric artery to enter the ring. It then traverses the inguinal canal, escapes through the superficial ring, and descends to the labium majus, where it breaks up into threads to be attached to the skin and superficial fascia of the labium.

Ligament of Ovary (Figs. 210, 222).—This also is a slender band of non-striped muscle mixed with fibrous tissue, but is only an inch or an inch and a half in length. It is attached to the intestinal surface of the uterus close to the uterine tube at the same level as the round ligament. From that attachment it passes to the uterine end of the ovary; it lies in the broad ligament and raises its upper layer into a ridge which is continuous with the mesovarium.

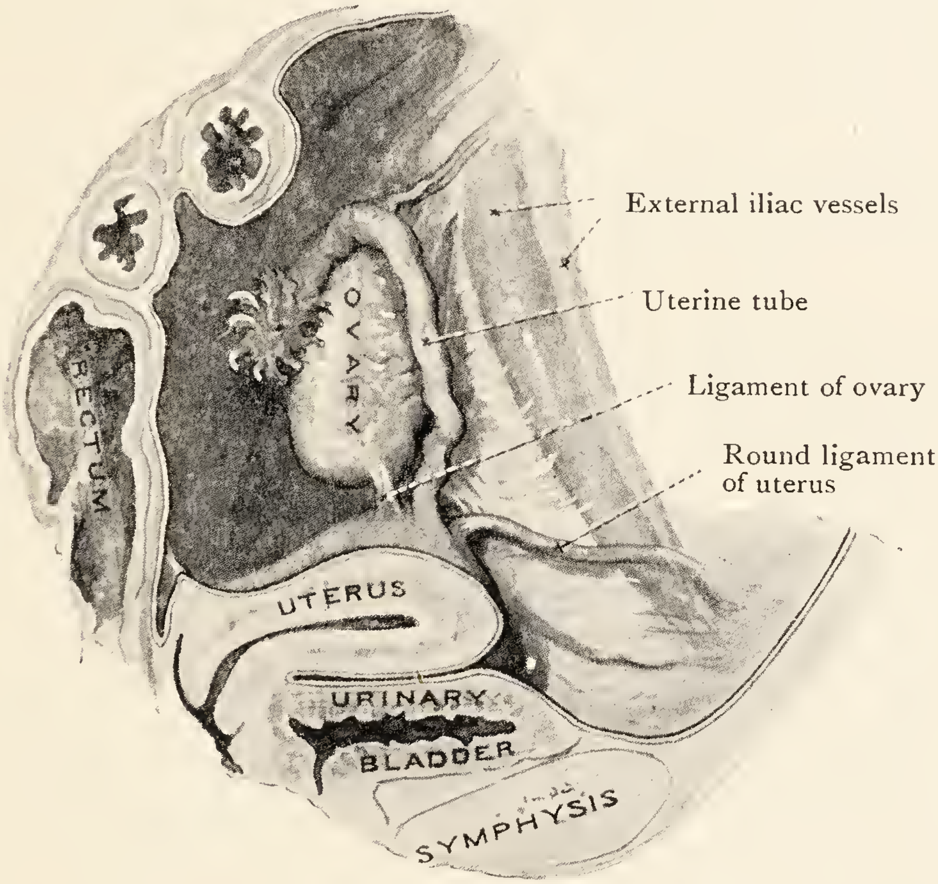

FIG. 222.—Left Side Wall of Female Pelvis to show position of Ovary. The ovary is much scarred owing to the shedding of ova.

Descent of ovary.—The ligament of the ovary and the round ligament of the uterus are derived from a band of embryonic tissue called the *gubernaculum* (p. 216). The embryonic genital gland is formed originally on the posterior wall of the abdomen near the kidney, and is connected with the skin below the rudimentary pubis by the gubernaculum.

In the female, the genital gland becomes the ovary and the skin below the pubis becomes the labium majus. The gubernaculum fails to keep pace with the growth of the rest of the body, but not to such an extent as in the male, for it draws the ovary down only to the pelvic brim. Being adherent to the junction between the developing uterus and uterine tube, the gubernaculum is divisible into two parts. The part between the uterus and the ovary becomes the ligament of the ovary, and the rest becomes the round ligament. As the pelvis enlarges, the uterus sinks into it and drags the ovary into the pelvis with it. In some rare cases, the ovary takes the same path as the testis and is drawn down into the inguinal canal or even into the labium majus; and trouble arises when the ovary enlarges at puberty.

As the ovary or the testis descends, its vessels and nerves elongate and keep pace with it.

Ovary (Figs. 210, 217, 221, 222, 235).—The ovary resembles a very large almond in size and shape. In a young woman, its surface is smooth and pink; later, it becomes grey, and, owing to the repeated discharge of ova through its surface, it becomes puckered by the formation of scars; and in elderly women it is shrunken and wrinkled owing to atrophy.

Position and Relations.—The ovary lies close to the side wall of the pelvis between the ureter and the broad ligament, and it is attached to the upper layer of that ligament. Its *tubal end* is immediately behind the external iliac vein, and the terminal part of the uterine tube curls round it. Its *uterine end* gives attachment to the ligament of the ovary. Its *medial surface* is overlapped by the tube and is related also to a loop of intestine. Its *lateral surface* is separated by the peritoneum of the side wall of the pelvis from the umbilical artery, the obturator nerve and vessels and the obturator internus muscle. Its *free border* is separated from the ureter by the peritoneum. Its attached or *mesovarian border* projects into the broad ligament through a slit in its upper layer, and is held in place by two exceedingly short layers of peritoneum called the *mesovarium.* The vessels and nerves enter and leave this border, which is therefore called the *hilum* of the ovary.

The position described is that usually occupied by the ovary of a nulliparous woman (one who has borne no children), but it is unlikely that the student will find it in that position in a multipara, for at the first pregnancy the broad ligament grows with the uterus and carries the ovary up into the abdomen proper; after childbirth, the organs return to the pelvis, but the ovary seldom regains its former position and may be found in any position in the dorsal part of the pelvis.

Vessels and Nerves of Ovary.—The *ovarian artery* springs from the aorta near the renal artery, runs downwards over the posterior wall of the abdomen, crosses the external iliac artery about an inch below its origin, enters the infundibulo-pelvic ligament, descends to the ovary and divides into branches that enter it through the hilum; a few twigs are given to the uterine tube, and the terminal twig anastomoses with a branch of the uterine artery.

The *veins* issue through the hilum and form a *pampiniform plexus* around the artery; two veins arise from the plexus at the brim of the pelvis; they soon unite into a single vessel which ascends alongside the artery; the right vein ends in the inferior vena cava, the left in the left renal vein.

The *lymph-vessels* emerge through the hilum and, joined by lymph-vessels from the fundus of the uterus and from the uterine tube, they ascend with the ovarian vein to the posterior wall of the abdomen, where they spread out to end in the aortic glands from the level of the termination of the aorta up to the renal vessels (Fig. 219).

The *nerves* are derived from the aortic and renal plexuses, and they accompany the artery.

Structure.—The ovary consists of:—(1) A surface layer of cubical cells called the *germinal epithelium*; in a young, fresh ovary, the junction between the cubical cells of the germinal epithelium and the squamous cells of the peritoneum is marked by a white line at the edge of the mesovarium. (2) A fibro-areolar meshwork, called the *stroma*, which is condensed at the surface to form a layer under the germinal epithelium. (3) A number of little sacs of varying size, called *ovarian follicles*, which are embedded in the stroma and contain the ripening ova; the largest are those which contain the ova nearest maturity, and they lie close to the surface, for an ovum leaves the ovary through a breach made on its surface by the swollen follicle, which ruptures to allow the ovum to escape.

The dissectors of the **female pelvis** *will now pass to the dissection of the left levator ani and medial pubo-vesical ligament described on p.* 456.

The dissectors of the **male pelvis,** *having completed the study of the ureter, will now proceed to the study of the vas deferens and seminal vesicle.*

The left vas deferens has been exposed as far as the bladder, and it is important that its relations should be studied now, before the parts are disturbed further. But its terminal part is concealed in the fascia behind the bladder and should now be defined.

Dissection.—Clean the *right vas deferens* as far as the bladder. Next, strip off the peritoneum between the bladder and the rectum, separating these organs as far as is necessary, and trace the right vas downwards over the back of the bladder and clean it. At the same time, clean the *right seminal vesicle*. Take great care at their lower ends, for the *ejaculatory duct*, which is formed by their union, is very slender and almost at

once sinks into the base or upper surface of the prostate. Then, define the *left vas* and *vesicle*, but do not displace them.

Vas Deferens (Figs. 204, 206, 216, 223, 233).—The vas deferens is the duct that conveys the products of the testis and epididymis from the scrotum to the pelvis.

Origin, Course and Termination.—It begins at the lower end of the epididymis as a continuation of the canal of the epididymis and runs upwards along its medial side over the back of the testis. At the upper part of the testis, it falls in with the other constituents of the spermatic cord and ascends with them from the scrotum to the superficial inguinal ring and then traverses the inguinal canal. At the deep inguinal ring, it leaves the other constituents of the cord, bends medially behind the root of the inferior epigastric vessels, and passes backwards into the pelvis.

In the pelvis, it runs backwards and slightly downwards over the side wall till it crosses the ureter near the posterior angle of the bladder. It then curves medially over the upper end of the seminal vesicle and, finally, descends over the back of the bladder to end behind its neck by joining the duct of the seminal vesicle to form the ejaculatory duct.

Relations in Pelvis.—In its course from the deep inguinal ring to the bladder, the vas is immediately under cover of the peritoneum, through which it can be seen ; and it crosses the following structures in turn—external iliac vessels, umbilical artery, obturator nerve and vessels, inferior vesical vessels, ureter and upper end of the seminal vesicle.

The portion that descends over the back of the bladder is dilated and sacculated ; this part is called the *ampulla* of the vas deferens and acts as a reservoir for the semen, to which it adds the secretion of its own mucous membrane. The ampulla is ensheathed in the fascia between the bladder and the rectum ; its lateral margin is closely applied to the seminal vesicle, while medially it is at first separated by an interval from the ampulla of the other side and then lies close alongside it at the median plane. Inferiorly, it narrows rapidly to end by joining the duct of the vesicle behind the neck of the bladder.

Seminal Vesicle (Figs. 206, 223, 230, 233).—The seminal vesicle is a lobulated sac about two inches long and half an inch in diameter. It is piriform in outline, with the blunt end above. Its lower end is called its duct and unites with the end of the vas deferens. It lies between the back of the bladder and the rectum, enclosed in a fascial sheath which binds it to the bladder. It lies obliquely so that its lateral surface looks downwards as well as sidewards and is related to the fat on the levator ani. The ampulla of the vas deferens lies along its medial surface. Its upper end is near the ischial spine close to the peritoneum ; the vas curves medially over it; and it overlaps the entrance of the ureter into the bladder.

When the vesicle is teased out, it is found to be a sacculated

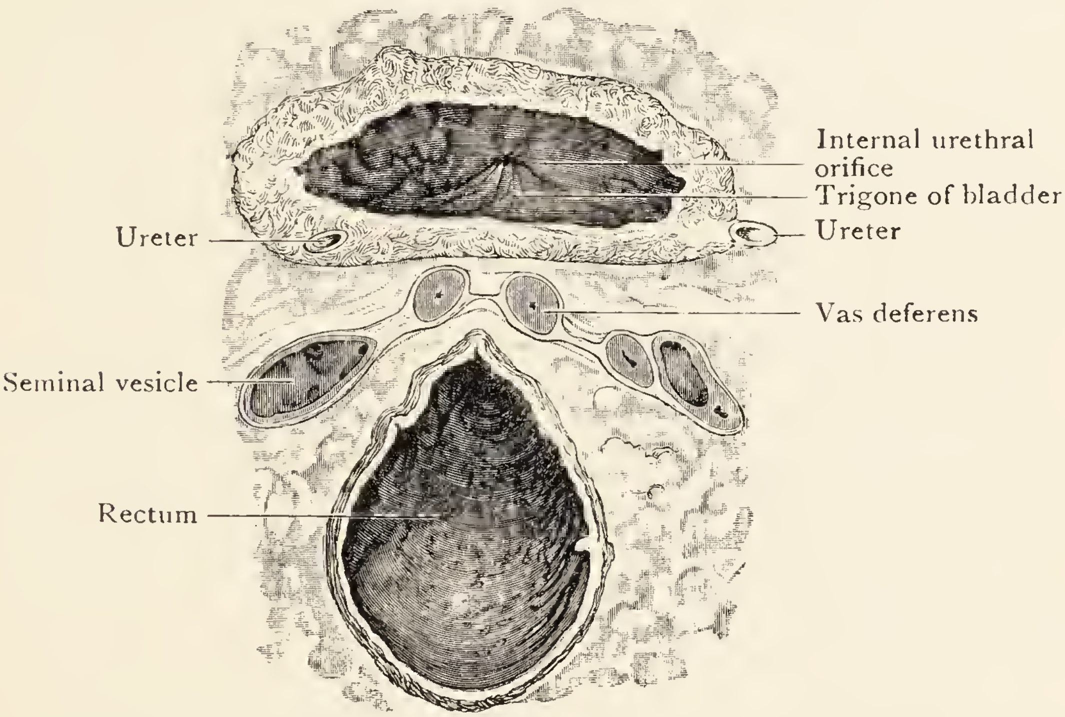

FIG. 223.—Horizontal Section through Bladder and Rectum at the level at which Ureters enter bladder.

tube about six inches long, with short sacculated branches ; but in the natural state it is folded and coiled into bag-like form.

The seminal vesicle does not appear to be merely a reservoir for the semen in the way that the gall-bladder is a reservoir for the bile ; in structure, it is identical with the ampulla of the vas deferens, and it is filled with the secretions of its own mucous membrane, which, in some way unknown, are essential for the maintenance of the activity of the spermatozoa.

Vessels of Vas Deferens and Seminal Vesicle.—The **arteries** to the vesicle and the ampulla of the vas are small branches of the vesical and middle rectal arteries ; the remainder of the vas is supplied by a long slender artery that usually springs from the inferior vesical artery, but sometimes comes from one of the superior vesical arteries. The **veins** end in corresponding veins. The **lymph-vessels** of the vesicle and the ampulla of the vas end in internal and external iliac glands.

Structure.—The walls of the vas, the vesicle and also the ejaculatory duct are in three layers :—an outer coat of fibrous tissue ; a middle coat of non-striped muscle ; and a lining of mucous membrane.

Ejaculatory Duct (Fig. 234).—This duct is the channel by which the contents of the seminal vesicle and the ampulla of the vas deferens are conveyed to the urethra. It is an exceedingly slender tube, little more than half an inch long, and is formed behind the neck of the bladder, close to its fellow of the opposite side, by the union of the vas deferens and the duct of the seminal vesicle. It enters the base of the prostate at once and passes downwards through the substance of the upper half of the prostate to enter the prostatic part of the urethra. It will be seen later that a diverticulum of the mucous membrane of the urethra, called the *prostatic utricle*, extends upwards into the prostate ; the two ducts diverge slightly from each other and run downwards along the sides of the utricle to open into the urethra at the margins of its mouth.

The dissectors of either **male pelvis** *or* **female pelvis** *will now expose the left levator ani muscle, and will define and study the pubo-prostatic or pubo-vesical ligaments.*

Dissection.—Pull the bladder backwards from the pubis, and define and clean the left *medial pubo-prostatic* or *pubo-vesical ligament* (p. 417). Identify the left *levator ani* from the perineum again. Then, **in the male pelvis,** pull the *bladder* and the *rectum* gently away from the side wall of the pelvis. **In the female pelvis,** divide the *ovarian vessels* and the *round ligament* at the pelvic brim, detach the *broad ligament* from the side-wall and floor of the pelvis, and draw *bladder*, *vagina* and *rectum* gently towards the right.

When the viscera have been drawn aside, pick away the remains of the fat from the fascia that covers the pelvic surface of the levator, and find its anterior border. It is lateral to the medial pubo-prostatic ligament, and passes obliquely backwards and medially from the back of the pubic bone past the side of the prostate or of the vagina. Remove the fascia from this border (avoiding injury to the medial pubo-prostatic ligament), and trace its fibres backwards to their insertion. Next, find and define the posterior border. Then, remove the fascia from the medial part of the muscle, but leave it intact on the lateral part, as its removal will probably injure the muscle.

The **levator ani** is described on p. 427. Before the dissectors study the pubo-prostatic (or pubo-vesical) ligaments, they should read the description of the levator ani again.

Pubo-Prostatic or Pubo-Vesical Ligaments.—**In the female**, the same description applies as follows for the male, with this exception that, there being no prostate in the female, the visceral attachment of the ligaments is to the neck of the bladder alone, and they are therefore named the *pubo-vesical ligaments*.

The *medial pubo-prostatic ligament* is a thick, short, strong fibrous band that contains some non-striped muscle. It springs from the pelvic surface of the body of the pubis close to the symphysis and passes backwards to be attached to the front of the neck of the bladder and to blend with the fascial sheaths of the prostate and the bladder, thus anchoring the bladder and the prostate. A thin, narrow fascial sheet unites it with its fellow of the other side, and the two of them form a lid over the anterior part of the gap between the anterior borders of the two levatores ani. They are the strongest, the most definite and the most important parts of the fascia of the pelvis ; at the side, each of them is continuous with a *lateral pubo-prostatic ligament*, which is merely the fascia on the anterior part of the levator ani and is connected with the fascial sheaths of the prostate and bladder at the side of the neck of the bladder.

The dissectors will now examine the rectum and anal canal.

Dissection.—Clean the *left sacral* and *coccygeal plexuses*, pulling the rectum over towards the right out of the way when the lower part of the sacral plexus is reached ; at the same time, clean the *piriformis* and the *coccygeus*. Then, clean the left side of the *rectum*, and also the *anal canal* down to the insertion of the levator ani. Now, replace the rectum, and clean its right side, and the right side of the anal canal both above and below the levator ani, and define the *ano-coccygeal body* behind the anal canal. Then, clear away the areolar tissue from the front of the lower part of the rectum ; but, **in the male**, preserve the sheet of fascia that forms the posterior part of the sheath of the prostate. At a lower level, define the anterior surface of the anal canal, and separate it from the remains of the *perineal body*.

Rectum (Figs. 204, 208, 220, 224, 225).—The rectum is the part of the alimentary canal into which the fæces pass from the colon to await discharge from the body by the act of defæcation. It is about five inches long, and its diameter varies with the bulk of its contents. Its lower part is called the *ampulla* of the rectum, because it is frequently more distended than the upper part—bulging forwards rather than sidewards.

The rectum is the continuation of the pelvic colon and lies low down in the dorsal part of the pelvis ; it begins on the pelvic surface of the third piece of the sacrum, proceeds

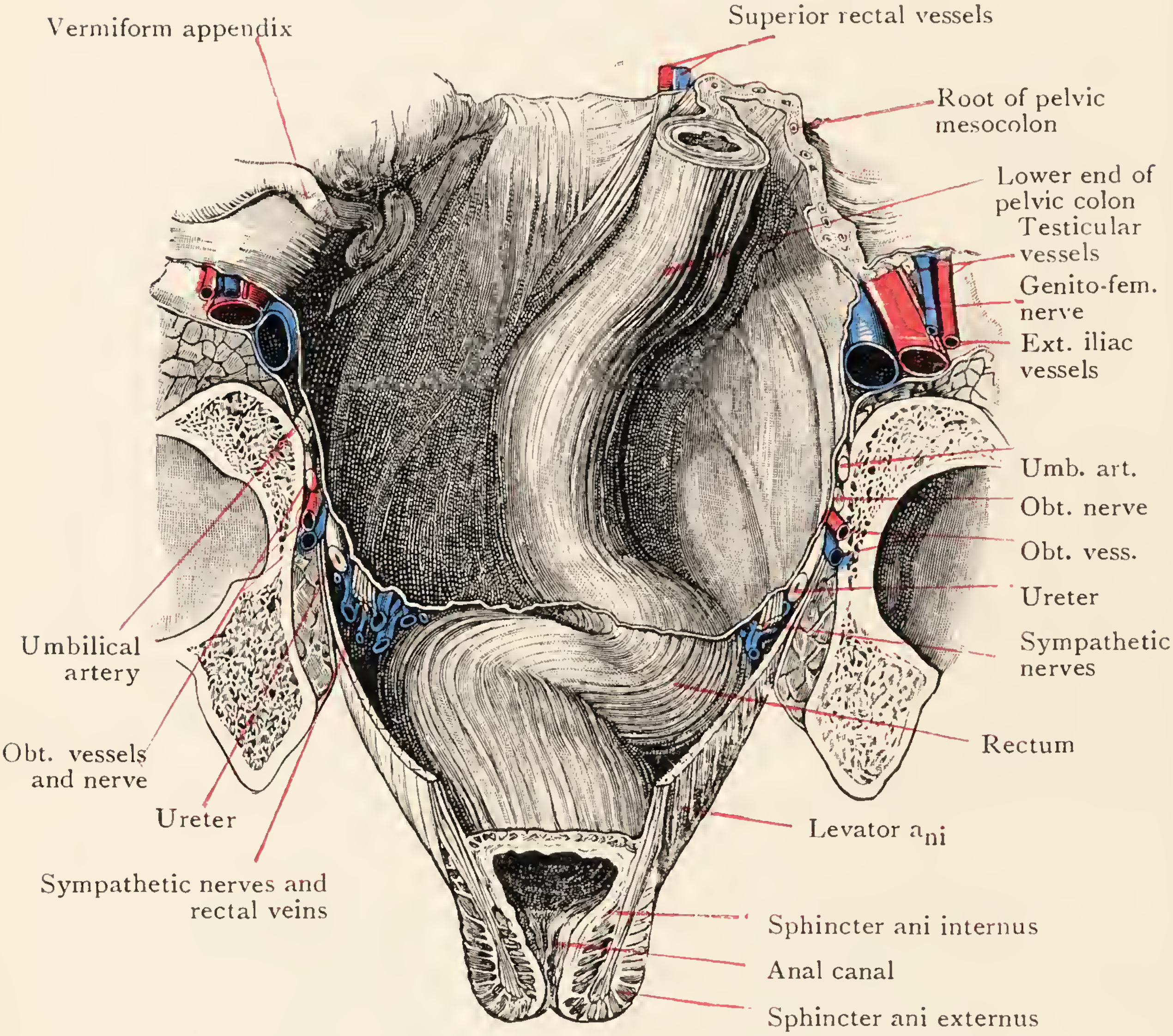

FIG. 224.—Dissection of Rectum from the front.

with a curve conforming to the curve of the sacrum and coccyx, and ends one inch beyond the tip of the coccyx behind the upper part of the perineal body ; at that level, which, in the male, is opposite the apex or lower end of the prostate, it bends backwards and becomes the anal canal.

Flexures of Rectum.—It derives its name " rectum " from the fact that in lower animals this part of the gut is straight. But the human rectum is far from straight. Besides its antero-posterior curve, it has three sideward bends ; the upper and lower of these *flexures* are concave towards the left, the middle one towards the right. They are most obvious when the gut is distended, but even when it is empty they are usually evident (Fig. 224).

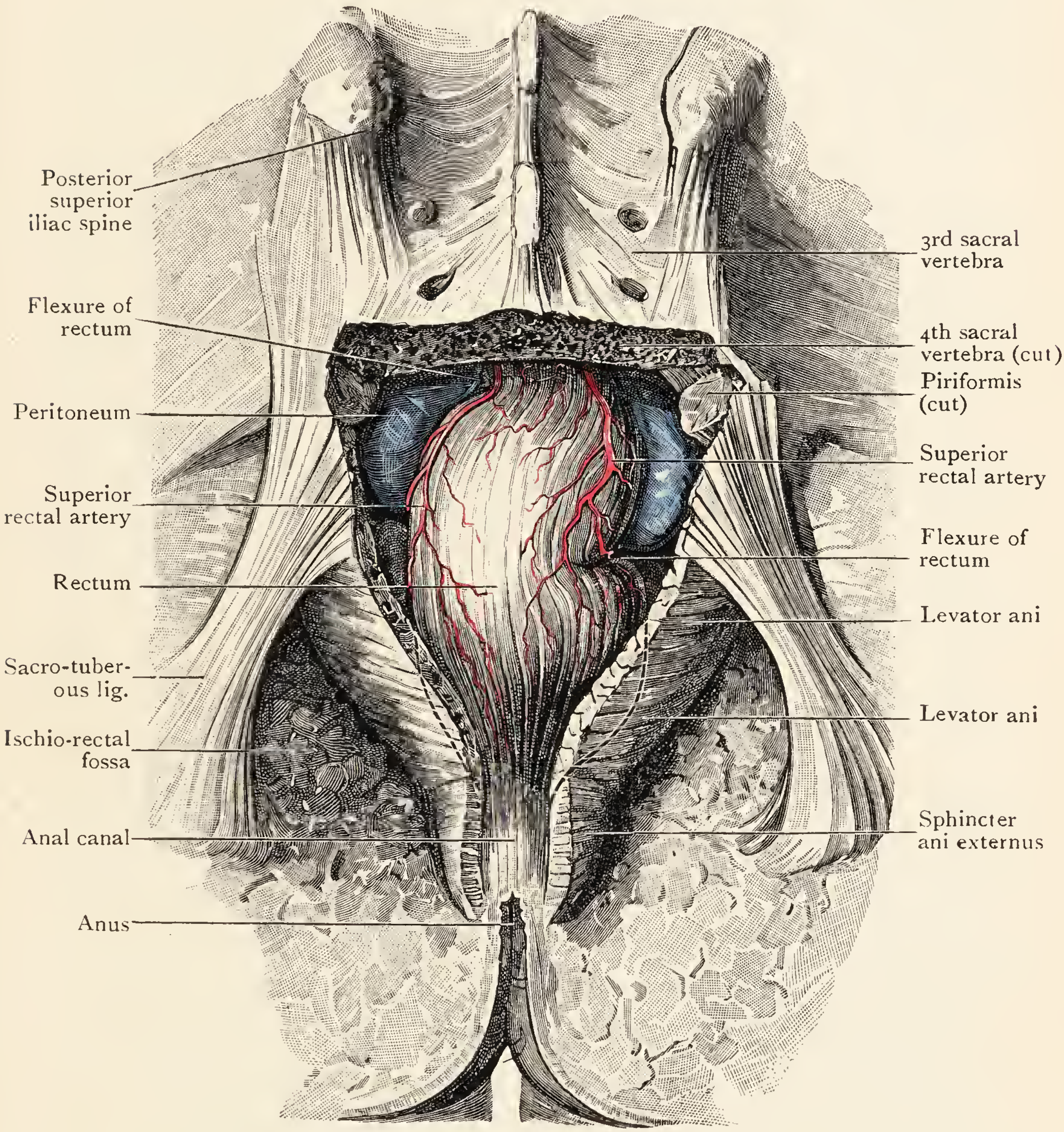

FIG. 225.—Dissection of Rectum from behind. (Birmingham)

Peritoneum of Rectum.—In its upper third, the peritoneum clothes its front and its sides ; but as the peritoneum is traced downwards it gradually clothes less and less of each side, till at the middle third it clothes only the front ; on each side, however, it usually reaches as far as the level of the middle flexure. At or near the junction of the middle and lower thirds the peritoneum leaves the front of the rectum and passes forwards on to the upper surface of the bladder—**in the male.** The lower third is therefore devoid of peritoneum—embedded in loose fascia below the level of the peritoneum.

The only difference in the peritoneal relations **in the female** is that when the peritoneum leaves the rectum it passes forwards on to the upper part of the back of the vagina and then onwards over the uterus.

General relations.—The structures related to the rectum *posteriorly* or dorsally are very numerous. The branches of the superior rectal (hæmorrhoidal) artery form the most intimate relation and come away with the rectum when it is removed. The sacrum, coccyx, and ano-coccygeal body in the middle and the piriformis, coccygeus and levator ani on each side form a smooth, curved bed in which the rectum lies. But between it and this bed there are smaller structures:—the median sacral vessels; the sympathetic trunk more laterally; and, still more laterally, the lower lateral sacral vessels, the lower sacral nerves and the coccygeal nerve. Structures that are farther back have to be borne in mind:—the contents of the sacral canal, the muscles on the back of the sacrum, the sacro-spinous and sacro-tuberous ligaments and the gluteus maximus.

On each side, the relations are more simple. The side of the upper third of the rectum, being clothed with peritoneum, is related to a loop of the ileum or the pelvic colon; the lower two-thirds is related to the fat on the coccygeus and levator ani, and to the condensed areolar tissue around the middle rectal (hæmorrhoidal) artery; this band of areolar tissue is bound to the sheath of the rectum and helps to keep it in place.

Anteriorly, **in the male,** the upper two-thirds, being clothed with peritoneum, is related to the ileum or pelvic colon; the lower third is separated from the bladder by the seminal vesicles and the vasa deferentia, and is directly related to the sheath of the prostate below the bladder.

In the female, the only difference is in the *anterior* relations. The upper two-thirds, being clothed with peritoneum as in the male, is related to intestines, which, however, separate the rectum from the uterus and the upper third (or less) of the vagina. The lower third is directly related to the middle third (or more) of the vagina.

The *recto-urethralis muscle* consists of weak bundles of fibres that pass from the front of the lower end of the rectum to the lower end of the prostate and to the urethra as it emerges from the prostate; in the female they pass to the back of the vagina. The muscle is seldom if ever seen in dissecting-room bodies.

Digital Examination per Rectum.—Restore the viscera as far as possible to their original position. Pass the fore-finger upwards through the anal canal into the rectum, and press it forwards. **In the female,** the *neck of the uterus* projects into the vagina; it is of firm consistence and will be felt through the walls of the rectum and vagina. **In the male,** the *prostate,* which is of firm consistence, will be felt as soon as the finger enters the rectum—about an inch and a half above the anus. At a higher level, on the back of the bladder, there are the seminal vesicles and vasa deferentia; and the finger will probably be able to distinguish between the coiled vesicle laterally and the smoother vas medially.

Anal Canal.—The anal canal is the terminal portion of the large intestine and is about an inch and a half long. It begins at the end of the rectum and passes downwards and backwards through the fascia and between the two levatores into the perineum, where it opens on the exterior at the anus. It is surrounded by fascia and by strong muscles which keep close guard over it and do not allow its lateral walls to separate from each other except during defæcation. These muscles are the two sphincters and the levatores ani.

The **internal sphincter** is a thickening of the circular non-striped fibres of the gut and is continuous with the circular fibres of the rectum; it surrounds the upper two-thirds of the anal canal. The *external sphincter* is described on p. 153; its deeper fibres closely encircle the lower two-thirds of the canal, overlapping the internal sphincter in the middle third. Some fibres of the *levator ani* are inserted into the side of the canal between the sphincters and mingle with the longitudinal non-striped fibres continued down from the outer layer of muscle of the rectum; and the "pubo-rectales" parts of the two levatores (p. 428) grasp the upper part of the canal and pinch in its sides.

Relations of Anal Canal.—*Posteriorly,* it is related to the ano-coccygeal body. *On each side,* its upper part is related to the levator ani, and its lower part to the ischio-rectal pad of fat.

Anteriorly, it is related to the perineal body, which, **in the male,** separates it from the transverse perineal muscles and the bulb of the penis, and, **in the female**, from the lower third of the vagina.

The dissectors will now examine the structure and the interior of the rectum and anal canal.

> ***Dissection.***—Open the *rectum* and *anal canal* by a longitudinal incision through the right wall as near as possible to the anterior median line. Sponge out the interior.

Structure of Rectum and Anal Canal.—The **rectum** has five coats—serous, fascial, muscular, submucous and mucous.

The *serous coat* is the peritoneal covering and has already been seen to be only partial. The *fascial coat* is a complete coat of areolar tissue loosely arranged except where the rectum is clothed with peritoneum; there, it is reduced to a very thin layer which connects the serous coat with the muscular coat.

The *muscular coat* consists of non-striped muscle arranged, as in other parts of the intestine, in an outer layer of longitudinal fibres and an inner layer of circular fibres. As the tæniæ coli approach the rectum, they increase in bulk, and spread out sideways to form the longitudinal layer, which, however, is not uniformly thick on all sides; it is massed on the front and on the back to form two broad bands that maintain the flexures and prevent the rectum from elongating as it becomes loaded.

The *submucous coat* is a loose layer of areolar tissue which allows the mucous coat to move freely on the muscular coat; it contains networks of vessels and nerves.

The *mucous coat* is thick and it is so movable that it may "prolapse" into the anal canal and even appear at the anus. It is frequently raised up into *horizontal folds*, and the lower folds, if well-marked, may impede the passage of a finger. They are three in number—one on the concave side of each of the three flexures—that is, two on the left wall of the gut and one on the right. Each is formed by an infolding of the mucous and submucous coats, and includes some of the circular muscle fibres. Their positions vary with the positions of the flexures. The right fold is usually the largest, and is about the level of the bottom of the recto-vesical (or the recto-vaginal) pouch of peritoneum. The other two are about an inch and a half above and below that level.

The **anal canal** has an outer fascial covering, a strong muscular coat (already described), and submucous and mucous coats—which, however, are limited to the upper two-thirds, for the lower third is lined with *skin*.

The *mucous coat* is thrown into longitudinal ridges called *anal columns*. The lower ends of the columns are connected by small semilunar folds called *anal valves*, which are situated at the junction of the mucous and cutaneous parts of the lining membrane. The valves bound little pockets called *anal sinuses*. The tearing down of an anal valve by a hard mass of fæces may be the starting-point of a breach of the lining membrane at the muco-cutaneous junction called *fissure in ano*—an intensely painful condition. The anal valves occupy the site of the part of the *cloacal membrane* which closed the anal end of the alimentary canal in the embryo. The membrane usually breaks down and disappears early in the third month of intra-uterine life ; but occasionally it persists, and the child is born with an "imperforate anus."

Vascular Supply of Rectum and Anal Canal.—The **arteries** are the five rectal arteries—a superior, a pair of middle and a pair of inferior—and a few twigs from the median sacral.

The **veins** form networks in the submucous coat and on the outer surface (p. 442), and these plexuses are drained by the veins that accompany the arteries.

The **lymph-vessels** (Fig. 194) end in widely separated groups of glands—superficial inguinal, sacral, internal and common iliac and inferior mesenteric.

The lymph-vessels of the lower part of the anal canal, together with those from the skin around the anus, run forwards in the perineum and then ascend to the superficial inguinal glands. From the remainder of the anal canal, lymph-vessels either run across the ischio-rectal fossa or ascend, with vessels from the lower part of the rectum, along the middle rectal vessels to internal iliac glands. Others from the rectum end in the sacral glands and the median common iliac glands ; but a group ascends with the superior rectal and inferior mesenteric veins to the inferior mesenteric glands. Some of the vessels are interrupted in the small glands that lie on the surface of the rectum (*pararectal glands*).

The dissectors will now turn their attention to the bladder.

Dissection.—Leave the *peritoneum* on the upper surface of the bladder, but trim it off along the margins. Pull the *bladder* away from the pubis, and clean its infero-lateral surfaces, but avoid injury to the *left medial pubo-prostatic* (or *pubo-vesical*) *ligament*, which is still in place.

Vesica Urinaria (Figs. 204, 206, 217, 228, 230, 231, 233). —The **urinary bladder** is a hollow viscus with strong muscular walls. It receives the urine from the kidneys through the ureters, and retains it until the muscular walls contract and expel it through the urethra in the process of micturition. It lies in the lower and anterior part of the pelvis immediately below the peritoneum, amidst the extraperitoneal fatty tissue, whose areolar element is condensed around it to ensheath it.

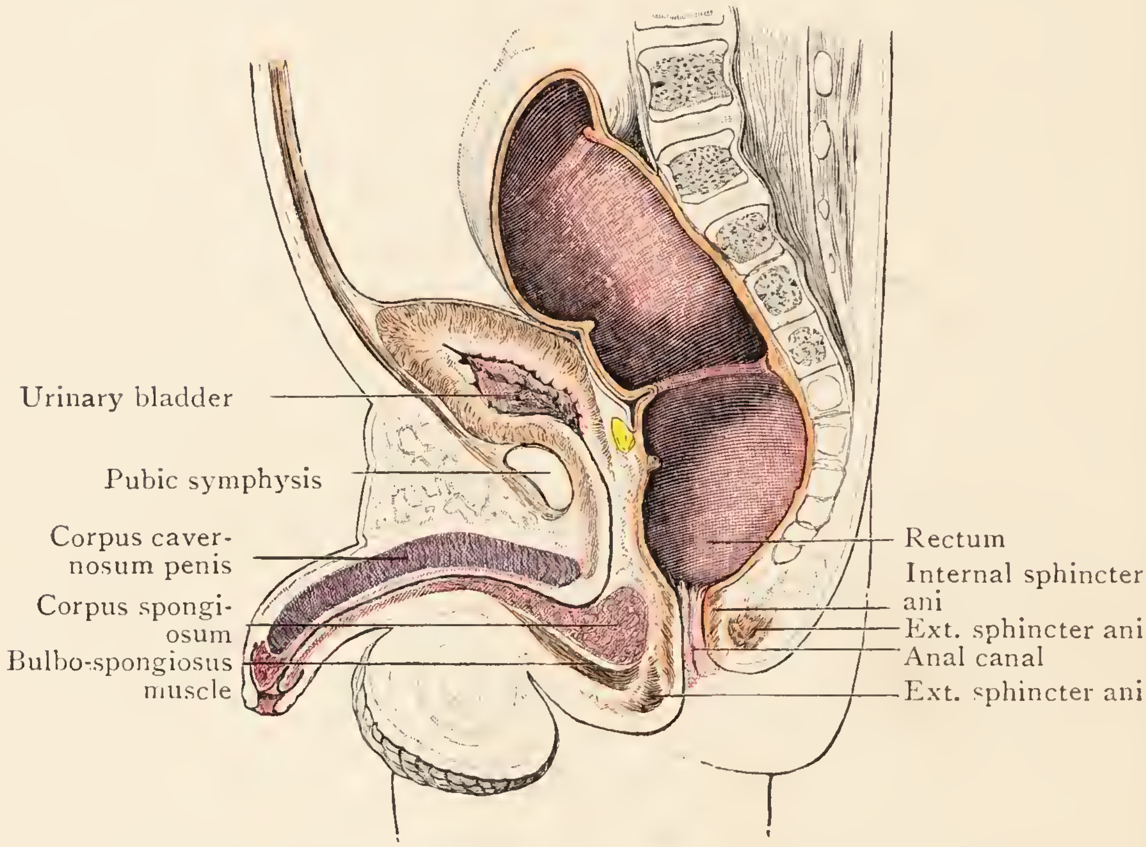

FIG. 226.—Median Section of Pelvis of New-born Male Child. (A. F. Dixon)

Position.—When the adult bladder is empty it lies wholly within the pelvis ; as it fills, its neck or lowest part remains stationary—being moored by the pubo-prostatic ligaments—and it therefore balloons upwards, lifting up the peritoneum and stripping it off the anterior wall of the abdomen. In this way a considerable portion of the bladder comes into contact with the transversalis fascia, and it can be reached therefore through an incision in the anterior abdominal wall without injury to the peritoneum.

In a child, the bladder, even when empty, is in contact with the abdominal wall, for at birth the pelvis is so small that the bladder is almost entirely in the abdomen proper, (Figs. 226, 227), and the peritoneum is reflected off the uterus on to its neck, or, in the male, even lower down—off the rectum on to the prostate. As the pelvis enlarges, the bladder gradually sinks into it, and the larger part of the empty bladder is accommodated in the pelvis by the sixth year; but it is not wholly a pelvic organ till shortly after puberty.

Shape and Surfaces.—The shape of the bladder varies with its degree of distension; a full adult bladder is spherical or

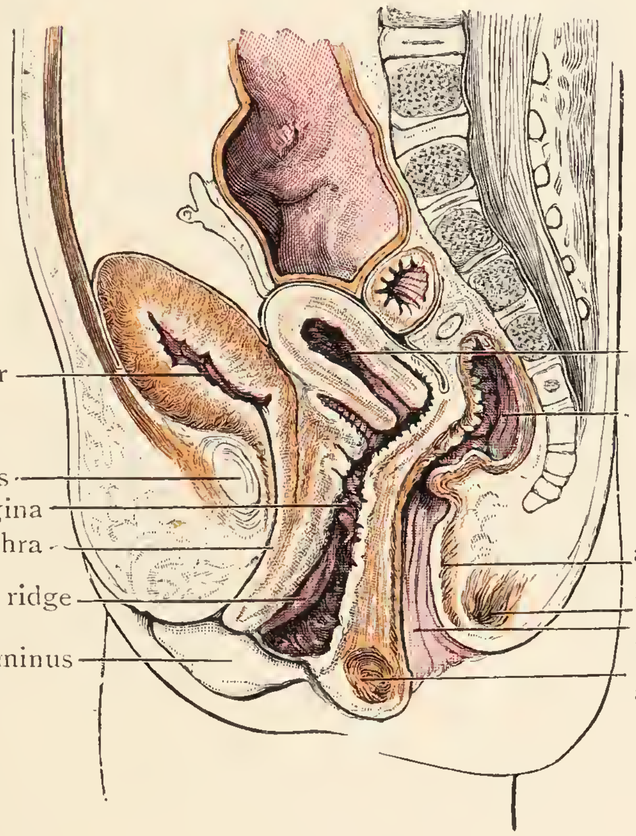

FIG. 227.—Median Section of Pelvis of New-born Female Child. (A. F. Dixon)

widely ovoid, and its surfaces merge into one another. In the cadaver, it may be empty, but usually contains a small quantity of urine. It may be found contracted or may be flaccid and collapsed under the weight of the intestines; but it is convenient to describe it under the shape which it retains after it has been hardened *in situ*.

In the infant, it has the form of an elongated oval, pointed at both ends; and the ureters enter it posteriorly near its lower end. Anteriorly, it is related to the transversalis fascia and the pubic bones; peritoneum covers its sides and its back, separating it laterally from small intestines, and posteriorly from pelvic colon and rectum; in the male, the seminal vesicles and vasa deferentia lie on the lower part of the posterior surface ; **in the female**, the peritoneum separates that portion from the uterus.

In an adult, the hardened empty bladder has the form of a three-sided pyramid placed on one of its angles. It has therefore an *apex*, a *base* and three surfaces—a *superior surface* and a pair of *infero-lateral surfaces*. The surfaces and the base are triangular in outline, are slightly convex, and are separated from one another by well-defined, blunt borders. The base and the infero-lateral surfaces meet at the *neck*, which is at the lowest angle of the bladder and is continuous with the urethra. Note that the neck, and not the base, is the lowest part of the bladder : the base looks backwards.

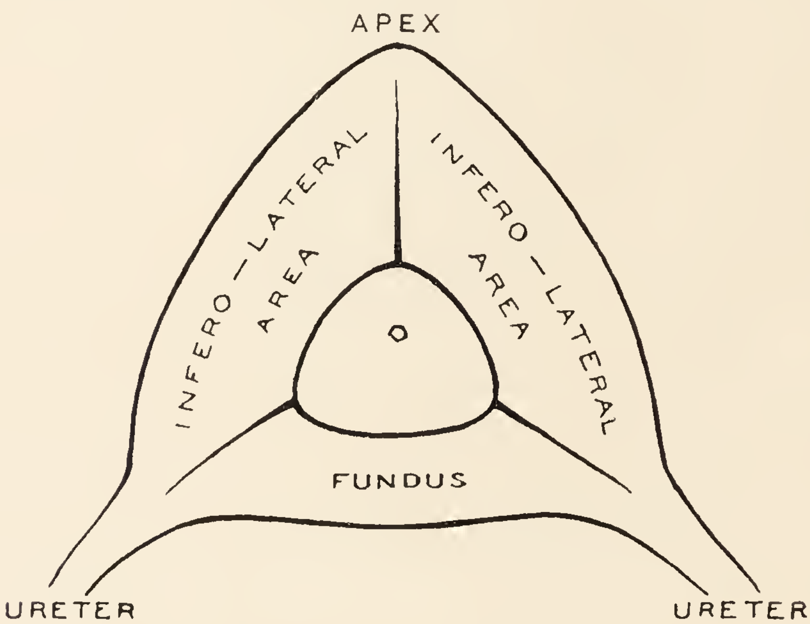

FIG. 228.—Diagram of Empty Bladder seen from below. (After A. F. Dixon) The enclosed area in the centre is the neck, and the small circle in it is the urethra.

Relations of Adult Bladder.—The **neck** is about an inch behind the pubic symphysis, a little above its lower border. *In the female*, it narrows abruptly to become continuous with the urethra. In front and at the sides, the pubo-vesical ligaments are attached to it ; and it is related posteriorly to the vagina. *In the male*, it is continuous with the prostate (which surrounds the first part of the urethra) ; it is connected with the pubo-prostatic ligaments in front and at the sides ; and posteriorly it is related to the commencement of the ejaculatory ducts.

The **apex** is the anterior angle of the bladder ; it is immediately behind the upper margin of the pubic symphysis, about an inch from the skin. It is continuous with a strong fibrous cord—the *median umbilical ligament*—which runs upwards in the median line of the back of the anterior abdominal wall to the umbilicus ; the ligament lies between the transversalis fascia and the peritoneum, and has been dissected already. It is the elongated and attenuated *urachus*—the shrunken cephalic (or upper) part of the ventral section of the cloaca of the embryo. Its lumen occasionally persists at birth ; and, in the adult, the vesical end of the

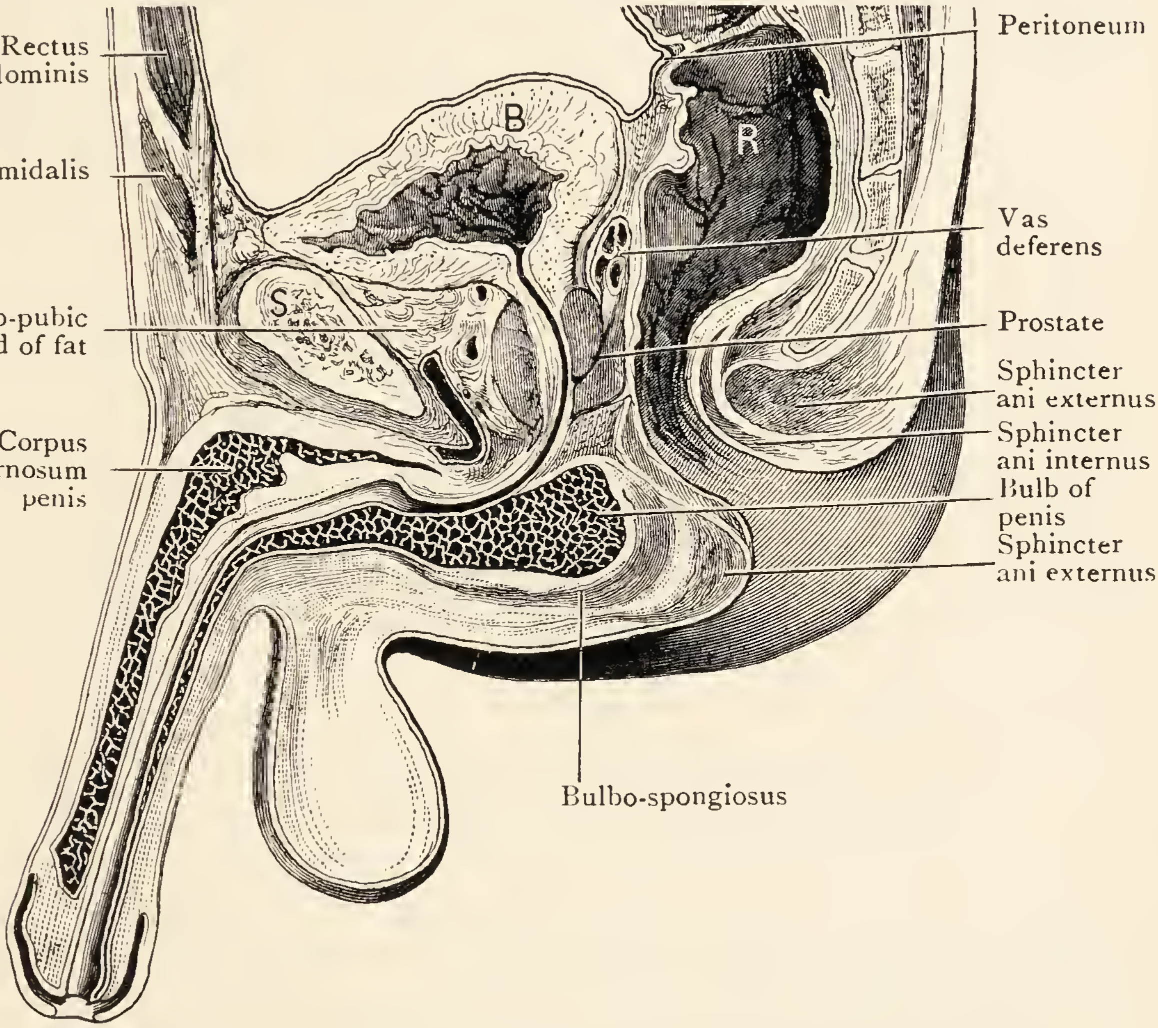

FIG. 229.—Median Section through Adult Male Pelvis. The Bladder is nearly empty, and the Urethra is divided along its whole length.

R. Rectum. S. Symphysis. B. Bladder.

ligament usually contains a narrow cavity which may or may not be continuous with the cavity of the bladder.

The **superior surface** is clothed with peritoneum, and, since the bladder is below the peritoneum, it is the only surface with a peritoneal coat (except a small area on the base in the male). The ureters join the bladder at the posterior angles of this surface, and the umbilical arteries run forwards parallel to its margins and come into contact with the bladder as it fills. **In the male,** the pelvic colon and coils of the ileum rest on the upper surface ; **in the female,** it is related to the overhanging uterus and a loop of the ileum. At the posterior border **in the female**, the peritoneum is reflected off the bladder on to the uterus at the junction of its body and neck ; **in the male**, it dips down to cover a small median area on the base before it is reflected on to the rectum.

The **infero-lateral surfaces** form the dorsal wall of the retropubic space. They are related to the retropubic fat, which separates each of them from the pubic bone, the obturator internus and the levator ani ; as the bladder fills, it comes into relation with a greater area of the side wall of the pelvis

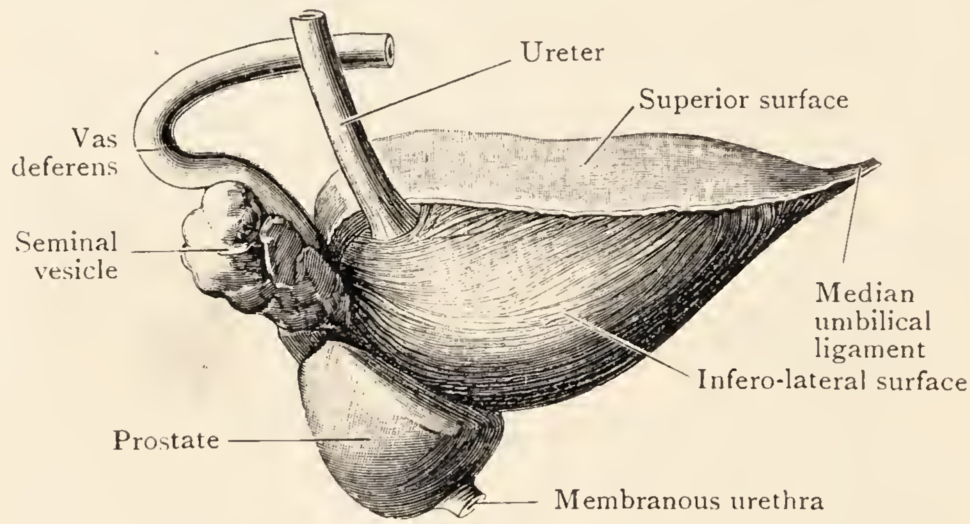

FIG. 230.—Bladder, hardened *in situ*, viewed from the right side. It contained a very small quantity of fluid. (A. F. Dixon)

and with the obturator vessels and nerve. The rounded *anterior border* between the infero-lateral surfaces is separated by the fat from the pubic symphysis and the medial puboprostatic or pubo-vesical ligaments.

The **base** or fundus is the **posterior surface** ; its upper border and angles are the same as the posterior border and angles of the upper surface, and the ureters begin to pierce the bladder wall at these angles. *In the female*, the base is related to the neck of the uterus and to the vagina. *In the male*, the seminal vesicles and the ampullæ of the vasa deferentia cover it, except the small area in the middle below the upper border which is covered with peritoneum of the recto-vesical pouch ; the pouch, the vasa and the vesicles separate it from the rectum.

The dissectors will now examine the structure of the bladder and its interior.

Dissection.—Raise the apex of the bladder ; enter the knife at the anterior border a little below the apex, and carry it backwards a little below the lateral margin of the upper surface—first on the one side and then on the other. Lift up the lid thus made, and sponge out the interior.

Structure of Bladder.—The bladder has five coats—serous, fascial, muscular, submucous, and mucous.

The **serous coat** of peritoneum is restricted to the upper surface (and to a small part of the base in the male).

The **fascial coat** is the layer of extraperitoneal tissue which ensheaths it. It is loose except on the upper surface, where it is reduced to the exceedingly thin layer which binds the serous coat to the muscular coat.

The **muscular coat** is a thick, strong layer of non-striped muscle, arranged in intersecting bundles which run in different directions. It is not possible to make a satisfactory display of them in a dissecting-room specimen ; but it should be noted that the greater part is arranged in coarse bundles that run obliquely and circularly round the bladder, and that at the neck the bundles become finer and are massed together to form a ring, called the *sphincter of the bladder*, which is continuous inferiorly with the muscular wall of the urethra in the female, and with the muscular substance of the prostate in the male.

The **submucous coat** is a layer of areolar tissue which forms a loose connexion between the muscular and mucous coats—except on the posterior wall, where the connexion is much closer. The blood-vessels and nerves ramify in it before they enter the mucous coat.

Mucous Coat and Orifices of Bladder.—When the bladder is full the **mucous coat** is smooth ; but it has little elasticity, and is therefore wrinkled when the bladder is empty—except over the trigone of the bladder. The **trigone** is a triangular area that occupies most of the inner surface of its posterior wall. In this situation, the mucous membrane is smooth even when the bladder is empty, because it is elastic and is tightly bound by areolar tissue to the muscular coat. It is also thinner than the rest of the mucous coat, and when the living bladder is examined through a *cystoscope* it appears pink, because it is thin enough to allow the blood in the blood-vessels to be seen through it.

There are three openings in the bladder—two of inlet and one of outlet—and they are situated at the angles of the trigone.

The openings of inlet are the **orifices of the ureters**. They are a pair of semilunar slits placed at the upper angles of the

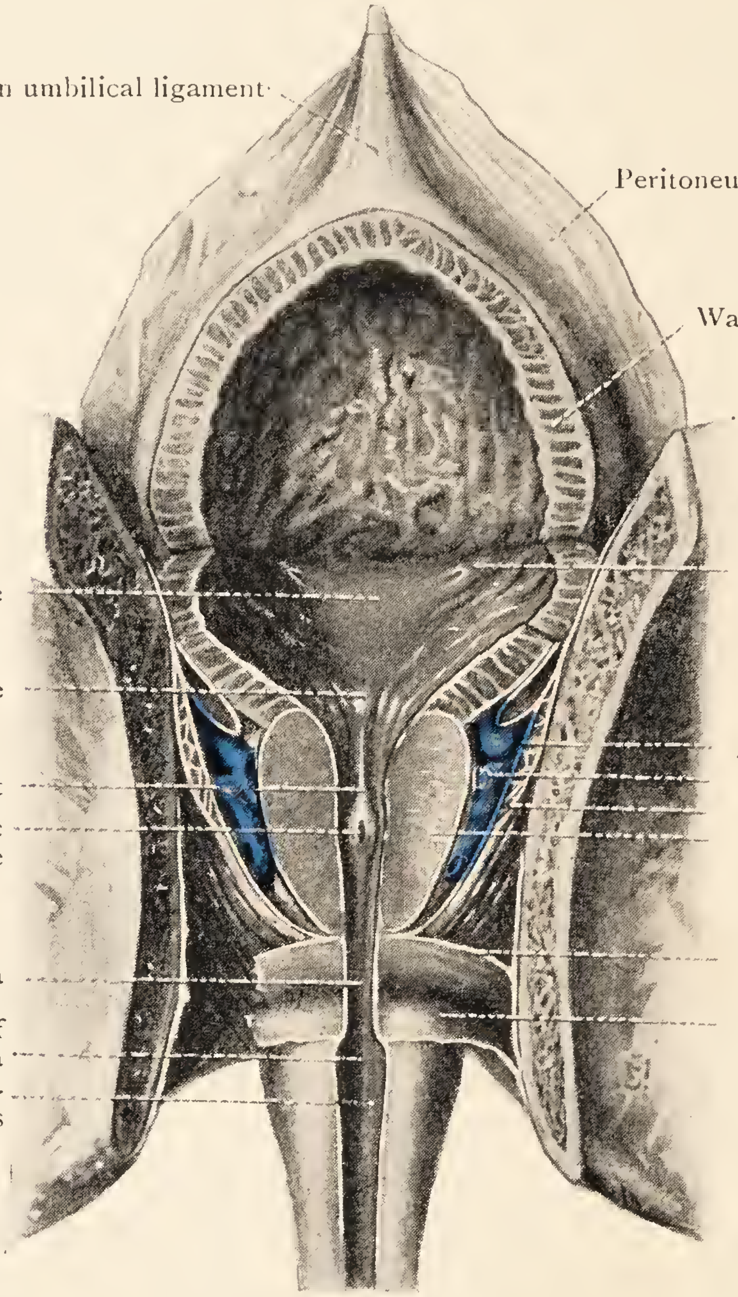

FIG. 231.—Dissection of Bladder and Urethra from the front. The sphincter of the urethra and the deep transversus perinei have been removed from the deep perineal pouch.

trigone, and they are often connected by an *interureteric ridge* of mucous membrane raised up by a bar of muscle. Pass a probe through the opening and into the ureter, and note that the ureter runs very obliquely through the substance of the bladder-wall for about three-quarters of an inch. This arrangement serves the purpose of a valve which allows urine to pass into the bladder, but prevents backward flow as the bladder fills. When the bladder is full, the orifices of the ureters are about an inch and a half apart, and about the same distance from the lower angle of the trigone ; but the sides of the trigone are reduced to one inch when the bladder is empty.

The opening of outlet is the **internal urethral orifice** at the commencement of the urethra. It is a Y-shaped slit situated at the lower angle of the trigone. Between the limbs of the Y, the mucous membrane, in the male, is bulged forwards by a part of the prostate called its median lobe ; the low eminence thus formed is called the *uvula of the bladder.*

Irregular permanent ridges of the mucous coat are often seen in elderly male subjects and are due to underlying muscular bundles which have become thickened in a general hypertrophy of the muscular coat of the bladder. This overgrowth is an attempt on the part of the bladder to overcome obstruction in the urethra—brought on usually by irregular enlargement of the prostate. The condition is known as *fasciculated bladder.*

Vessels of the Bladder.—The chief **arteries** on each side are the superior vesical branches of the umbilical artery and the inferior vesical branch of the internal iliac.

The **veins** form plexuses which are most dense around the neck and around the ends of the ureters. The plexuses are drained by the inferior vesical veins.

The **lymph-vessels** (Fig. 194) of the anterior part of the bladder pass to the external iliac glands, some of them being interrupted in small glands that lie on the infero-lateral surfaces. From the posterior part, a few pass to the external iliac glands, but most go to the internal iliac glands. Vessels from the neck are associated with those from the prostate that run to the sacral and median common iliac glands.

The dissectors of a **male pelvis** *will now proceed to examine the prostate. The dissectors of a* **female pelvis** *will turn to p. 478 and make their final dissection.*

Dissection.—Remove the fascia and the veins from the sides of the *prostate*, if that was not done when the levatores ani were cleaned. Define the posterior part of the sheath of the prostate, and leave it in place ; it is usually fairly definite, for it is part of a sheet of fascia called the *recto-vesical septum.*

Clean out the space below the medial pubo-prostatic ligaments.

That entails the removal of the anterior parts of the fascial sheath and venous plexus of the prostate. As the veins are removed, look for the *deep dorsal vein of the penis*, which joins them. Near the lower end of the prostate, be careful to avoid injury to the *urethra* as it emerges from the prostate. Secure it at that point, and trace it down to the penis.

Prostate (Figs. 204, 214, 230, 231, 233, 234).—The prostate is present only in the male. It is a solid, musculo-

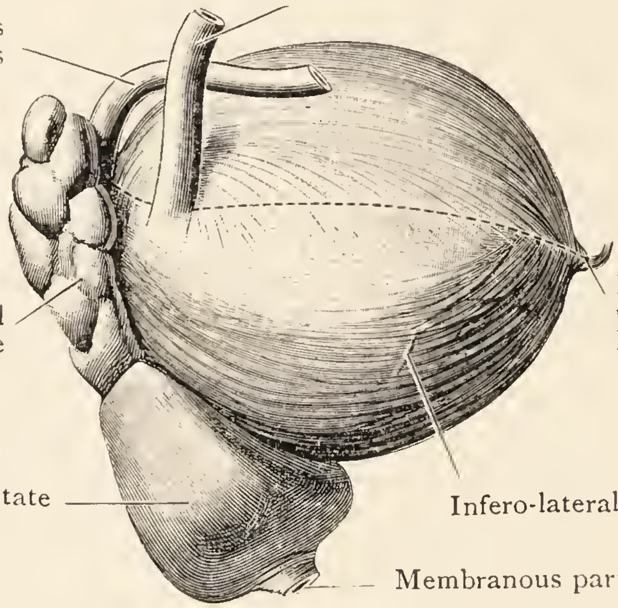

FIG. 232.—Bladder, hardened *in situ*. It contained a slightly larger amount of fluid than the specimen depicted in Fig. 230. (A. F. Dixon)

glandular body that lies immediately below the bladder and surrounds the first part of the urethra. Its function is not known, except that its secretion is concerned in some way with the vitality of the spermatozoa. Its secretion is added to the semen or seminal fluid. (The *semen* is derived from various sources. It is essentially the secretion of the testes but it includes also the secretions of the epididymides, vasa deferentia, seminal vesicles, prostate and bulbo-urethral glands.)

The prostate derives its name from the fact that it is placed at the exit from the bladder and, as it were, stands guard over it. (*Prostatēs* means one who stands in front: a protector.) It is of fairly firm consistence, and resembles an inverted compressed cone—measuring an inch and a quarter from base to apex, and an inch and a half across the base.

Relations of Prostate.—Its *base* is partly continuous with the bladder at its neck and is partly separated from the bladder by a circular groove in which fat and fascia and veins are lodged. The pubo-prostatic ligaments are connected with the front and sides of the base; and, posteriorly, the ejaculatory ducts enter it.

The *apex*, or lower end, rests upon the fascia that covers the pelvic surface of the sphincter urethræ; and the urethra

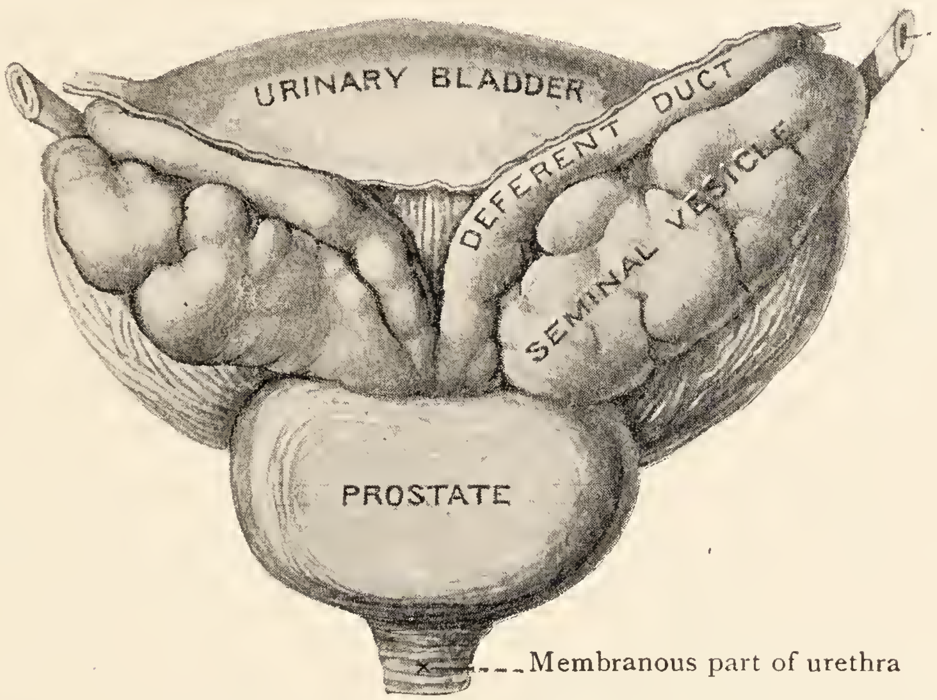

FIG. 233.—Bladder, Seminal Vesicles and Prostate, from behind.

emerges through the anterior border immediately above the apex (Fig. 232).

Each *lateral surface* is highly convex; it rests against the anterior part of the levator ani; and the anterior borders of the two levatores clasp the lower part of the prostate between them. Pull the bladder and the prostate towards the right, to see the relation to the left levator. The two lateral surfaces meet at a very blunt *anterior border*, which is separated by a quantity of fatty areolar tissue from the lower part of the pubic symphysis.

The *posterior surface* is flat. It is related to the lowest part of the front of the rectum, from which its sheath is separated by some fatty areolar tissue.

Sheath of Prostate.—The whole prostate is enclosed in a **fascial sheath.** It is important to note that the prostate lies loosely in its sheath. It is firmly connected with it where the urethra emerges; elsewhere, it is connected by loose areolar tissue in which the prostatic plexus of veins is embedded.

Externally, the sheath is connected by loose areolar tissue with the fascia on the surrounding parts—rectum, levator ani and sphincter urethræ.

Recto-Vesical Septum.—The sheath is strongest posteriorly, where it is formed by the lower part of a sheet of fascia called the *recto-vesical septum.* The septum is connected inferiorly with the perineal body, and extends upwards in front of the rectum, behind the prostate, vasa deferentia and seminal vesicles to be attached to the peritoneum that forms the floor of the recto-vesical pouch. Its connexion with the peritoneum indicates its origin. In early fœtal life, the recto-vesical pouch extended downwards as a recess in front of the rectum as far as the apex of the rudiment of the prostate. In the course of development, this recess was obliterated, and the two layers of peritoneum that formed its walls fused together to form the greater part of the thickness of the recto-vesical septum.

Vessels of Prostate.—The **arteries** are twigs from the nearest visceral branches of the internal iliac—the inferior vesical above, and the middle rectal behind. The **veins** pass into the plexus around it (p. 442).

On each side, **lymph-vessels** run partly in company with those from the seminal vesicle and the ampulla of the vas deferens to the external and internal iliac glands, and partly with those from the neck of the bladder to the sacral and common iliac glands (Fig. 194).

Structure and Divisions of Prostate.—The prostate is composed of minute tubular glands mingled with non-striped muscle and fibrous tissue. The ducts of the glands—twenty or more—are very minute and open into the prostatic part of the urethra. The muscular and fibrous tissue is most abundant at the surface, where it forms a condensed layer called the *capsule.* Note that the capsule of the prostate is part of its own substance, while the sheath is the fascia around it, and that the capsule is only loosely connected with the venous plexus and the sheath.

The urethra traverses the prostate from base to apex. Half way down the prostate, the mucous membrane of the posterior wall of the urethra is evaginated to form a narrow diverticulum called the **prostatic utricle.** The utricle extends upwards and backwards in the substance of the upper part of the prostate, and the ejaculatory ducts descend along its sides. The portion of the prostate that separates the urethra from the utricle and the ducts is called its *median lobe.* The rest of the prostate is spoken of as being divided into *right* and *left lobes*, but there is no structural demarcation between them except the passage of the urethra. The upper part of the median lobe bulges upwards and forwards producing the eminence called the uvula of the bladder.

In the specimen under dissection, it is more than possible that the dimensions of the prostate will be greater than those given, for enlarge-

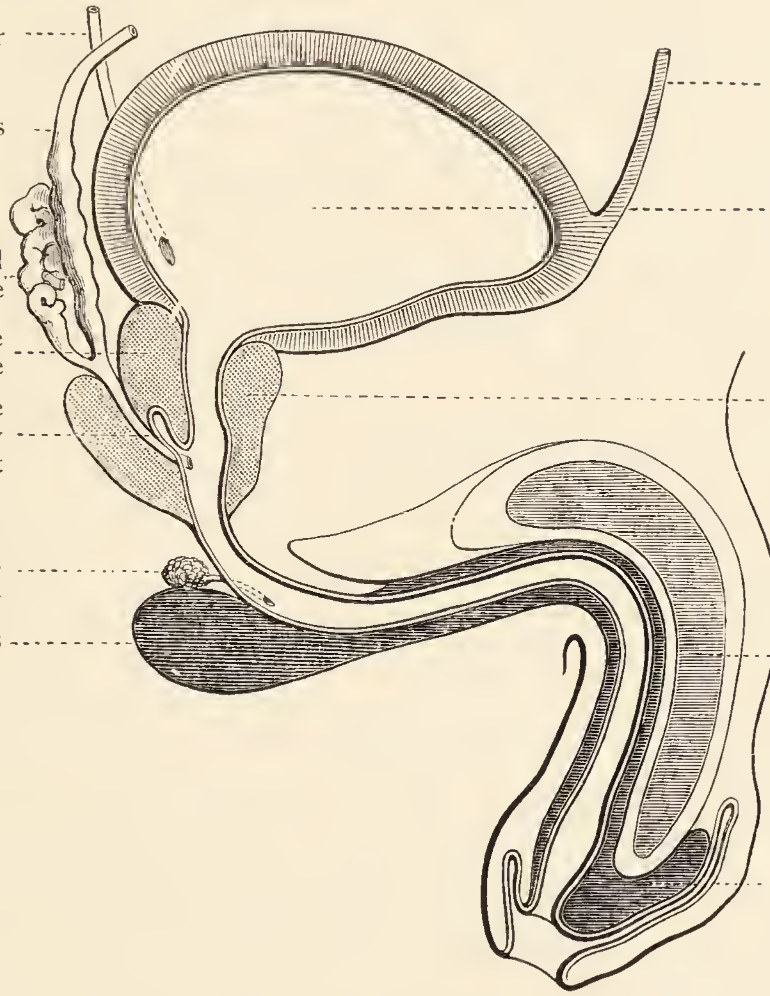

FIG. 234.—Diagram of Bladder, Urethra, and Penis. (Délépine)

ment of the prostate is common in old men. If the enlargement is uniform the contained urethra is merely lengthened. But if it is localised the urethra may be kinked or compressed ; and an enlarged median lobe may bulge forwards into the bladder and form a kind of lid over the urethral orifice. In such circumstances, micturition becomes difficult or impossible, and the urine has to be drawn off periodically by catheter. Rather than submit to continued " catheter-life," the sufferer may prefer to have his prostate removed—an operation less difficult and dangerous than might be surmised.

The final stage in the dissection of the **male pelvis** *is the examination of the urethra.*

Dissection.—Make a median incision through the anterior border of the bladder, and continue the cut through the anterior part of the prostate, laying open the *prostatic part of the urethra* from the front. Next, lay open the *membranous part* in like manner, and, finally, the *spongy part* by a median incision along the dorsum of the penis—if that has not been done already.

Male Urethra (Figs. 204, 231, 234).—The urethra is the canal through which the urine, the semen and the secretions of its own mucous glands are discharged from the body.

Structure.—The walls of the urethra are composed of :—(1) a coat of non-striped muscle with which fibro-elastic tissue is mingled ; (2) a very vascular submucous coat of areolar tissue ; and (3) the mucous lining. The mucous coat contains small mucous glands, and it is pitted by a large number of minute recesses called *urethral lacunæ*, whose mouths are directed distally. The submucous coat contains numerous mucous *urethral glands*, whose ducts pierce the mucous membrane.

Course and Divisions.—The male urethra is about eight inches long. It begins at the neck of the bladder, traverses first the prostate, next the sphincter urethræ muscle, and thirdly the corpus spongiosum of the penis; and it terminates on the end of the glans at the *external orifice*, which is the narrowest point of the urethra and the least dilatable point. In its course, the urethra makes an ∽ shaped bend—when the penis is dependent—first downwards, then forwards, and then downwards again.

For convenience of description, the male urethra is divided into three parts corresponding to the three structures which it traverses—prostatic part, membranous part and spongy part.

Characters and Relations.—The **prostatic part** is about an inch in length. It begins at the neck of the bladder, enters the base of the prostate at once, descends through it and emerges at the anterior border immediately above the apex. It is the widest and most dilatable division of the urethra, and it is wider in the middle than at its ends. The mucous membrane of its posterior wall presents several features for examination—the urethral crest, the prostatic sinuses, the mouth of the prostatic utricle and the openings of the ejaculatory ducts.

The *urethral crest* is a narrow, median ridge of mucous membrane that begins at the internal urethral orifice, descends in the posterior wall of the prostatic urethra, swells into a rounded eminence half-way down, and then suddenly diminishes and fades away into the membranous part, sometimes bifurcating before it disappears. The *prostatic sinuses* are the pair of grooves along the sides of the crest; the ducts of the glands of the prostate open into them.

At the lower part of the rounded eminence, there is a small opening that leads into the *cul-de-sac* of mucous membrane called the *prostatic utricle.* The utricle, as stated already, extends upwards and backwards into the prostatic substance, behind the urethra, for nearly half an inch. It is of interest in respect that it is the homologue of the uterus and vagina; and it is of practical importance because it may catch the point of a small catheter or a small bougie. Pass a probe gently into the utricle, gauge its length, and note that its mouth is the narrowest part of it.

The *ejaculatory ducts* open into the urethra by minute slit-like orifices at the sides of the mouth of the utricle. Pass a bristle up through one of them.

The **membranous part** is half an inch or less in length and is the narrowest and least dilatable division of the urethra. Note that, though the membranous part is the narrowest *division*, the external orifice is the narrowest *point* of the urethra, and that therefore any instrument that can be passed through the orifice can be passed along the whole length of the healthy urethra. The membranous part begins at the lower part of the prostate, pierces the fascia on the pelvic surface of the sphincter urethræ at once, passes downwards and forwards enclosed in the sphincter, pierces the perineal membrane and enters the bulb of the penis to become the spongy part. Immediately after it pierces the perineal membrane it widens slightly, and its posterior wall comes into contact with the bulb at once, but the anterior wall is unprotected for a fraction of an inch; this part is liable to be ruptured during the passage of a catheter if force is used, or if the catheter is depressed too soon, in the attempt to manœuvre the instrument past the perineal membrane.

The membranous part is not more membranous than the other divisions; it receives the name because it lies between two membranes—the pelvic fascia and the perineal membrane. As it perforates the fascia, its walls are adherent to the margin of the aperture through which it passes.

The **spongy part** is much the longest division of the urethra, and it traverses the corpus spongiosum lengthwise. It begins at the upper surface of the bulb of the penis—which is the enlarged posterior end of the corpus spongiosum. Conforming to the shape of the bulb, the urethra expands as soon as it enters the bulb—its lower wall bulging downwards into it, forming a well called the *intrabulbar fossa.* The corpus spongiosum enlarges also at its anterior end to form the glans penis. The urethra conforms again. It enters the lower part of the glans and expands upwards into it to form a slit-like recess called the *fossa terminalis* (fossa navicularis), which may be bounded posteriorly by a fold of mucous membrane in the roof of the urethra. When a catheter or a bougie is passed, its point is run along the floor of the urethra till it is beyond the glans, lest it be caught in the lacuna or recess thus formed (Fig. 113, p. 229).

Vessels and Nerves of Urethra.—The urethra receives a share of the blood-supply and nerve-supply of the prostate and penis. The lymph-vessels of the prostatic part accompany those of the prostate (p. 474). Those of the membranous and spongy parts end in the external and internal iliac glands, but some of those from the spongy part end in the deep inguinal glands.

The examination of the **male pelvis** *is now completed.*

The dissectors of the **female pelvis,** *having completed the study of the bladder, will now proceed to examine the urethra, the uterus and uterine tubes, and the vagina.*

Dissection.—Pull the bladder and the uterus towards the right, and clean the left side of the vagina down to the level of the levator ani. Next, replace the viscera and, from the right side, clear the fat and fascia and veins from the space below the medial pubo-vesical ligaments, and define the *urethra* on the anterior wall of the vagina. As the veins are removed, look for the *dorsal vein of the clitoris*, which joins them.

Then, bisect the bladder, urethra, uterus and vagina. Begin with a median incision through the antero-inferior wall of the *bladder*, and continue to cut carefully downwards through the anterior wall of the *urethra*. Next, carry a median incision through the upper and posterior walls of the bladder and the posterior wall of the urethra ; separate and remove the right half of the bladder and urethra.

Lastly, bisect the *uterus* and the *vagina* ; separate the right half of the vagina from the rectum and the perineal body, and remove it along with the right half of the uterus. Retain the right half of the uterus and vagina, and replace them when the relations of these organs are studied.

Female Urethra (Figs. 207, 217, 221).—The urethra is the canal through which the urine is discharged from the body. It is an inch and a half in length; and it is wider and more dilatable than the male urethra.

Course and Relations.—The urethra begins at the neck of the bladder and passes downwards and forwards to open by a slit-like orifice in the vestibule of the vagina immediately in front of the orifice of the vagina. Its uppermost part is surrounded by fibres of the sphincter urethræ muscle. Anteriorly, it is separated by fatty tissue from the medial pubo-vesical ligaments and the pubic symphysis. Posteriorly, it is closely related to the vagina and is, indeed, partly embedded in its anterior wall; in consequence of its intimate relation to the vagina, it is stretched and is liable to be bruised against the pubis when the vagina is stretched by the head of the child during parturition.

Structure.—Three layers are recognised in the walls of the urethra — muscular, submucous and mucous. The *muscular coat* of non-striped muscle is continuous with that of the bladder. At the lower end, it is largely replaced by fibrous tissue which provides the external orifice with firm, prominent margins that enable the orifice to be identified by the finger-tip when a catheter has to be passed. The *submucous coat* consists of very vascular areolar tissue. Near the lower end, it contains a group of small glands on each side; the ducts of these glands unite to form a slender tube, called the *para-urethral duct*, which opens at the margin of the external orifice. These glands may be homologous with the glandular substance of the prostate.

The *mucous coat* is arranged in longitudinal folds which permit dilatation of the urethra. It is pitted by small recesses called *urethral lacunæ*, whose mouths are directed downwards; and it contains mucous *urethral glands*.

Vessels of Female Urethra.—The **blood-supply** is from the inferior vesical and internal pudendal vessels.

The **lymph-vessels** pass to the sacral and iliac glands.

Uterus (Figs. 217, 221, 235-237).—The uterus is the hollow, muscular organ in which the fertilised ovum is retained until the fœtus is fully developed.

Dimensions and Parts.—The uterus is three inches in length; it measures about two inches across its free end, and gradually diminishes to one inch; and its thickness is

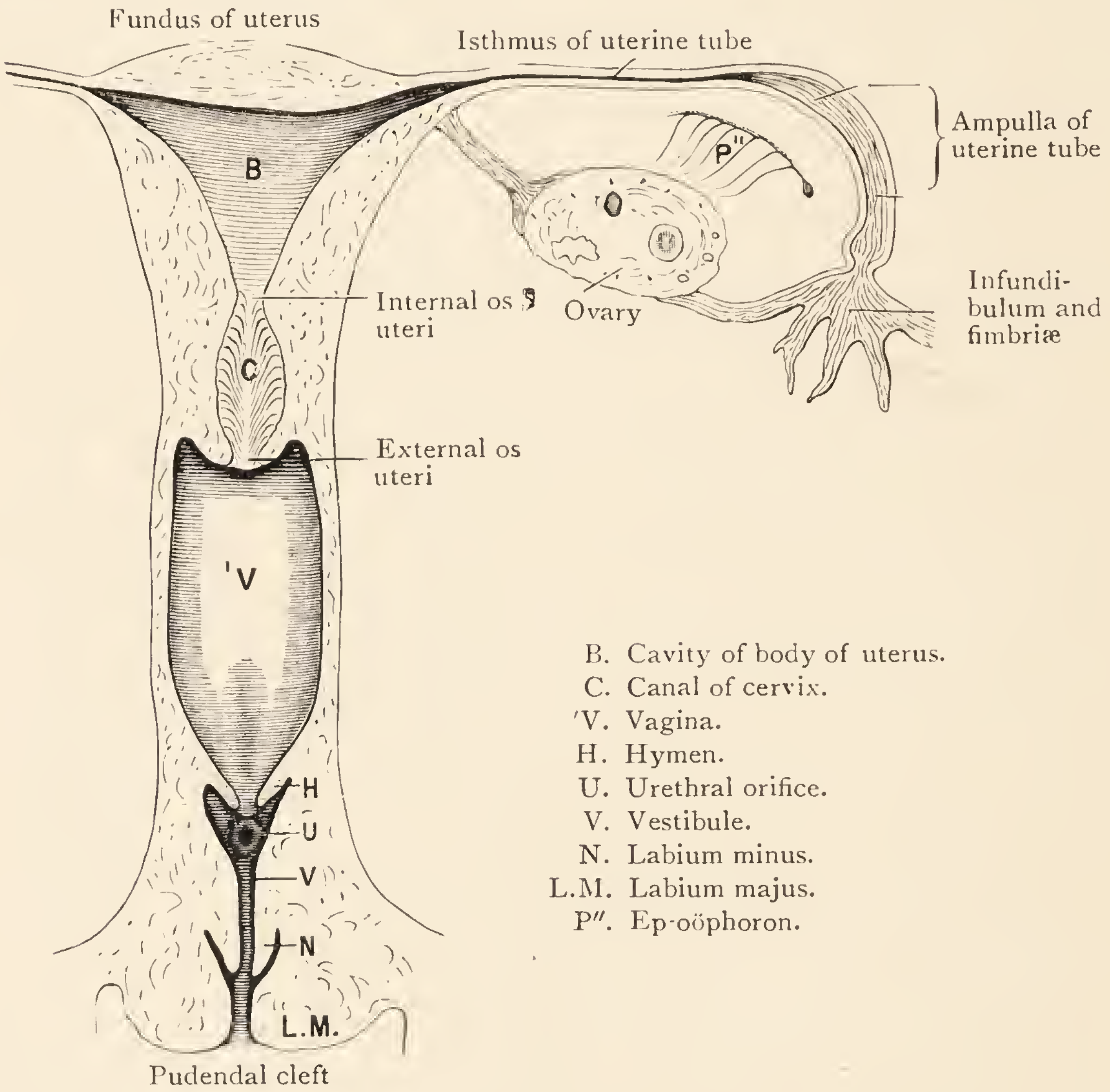

FIG. 235.—Diagram of Female Genital Organs. (Symington)

one inch. The part connected with the vagina is therefore cylindrical; it is called the *neck* or *cervix*, and is one inch long. The remainder is the *body*; its junction with the neck is called the *isthmus*, and is marked by a faint groove until the first pregnancy; the free end is rounded and is called the *fundus*. The uterine tubes pass laterally from the sides of the fundus; close to each tube, the ligament of the ovary is attached to the intestinal surface of the uterus, and the round ligament to the vesical surface.

Position and Characters.—The uterus lies in the middle of the pelvis, on the posterior part of the upper surface of the bladder, beneath coils of intestine. It is at right angles to the vagina and to the plane of the pelvic brim (Fig. 217). Being thus inclined forwards from the vertical axis of the trunk, the normal uterus is spoken of as being in the position of *anteversion.*

It is seldom quite median in position; it leans usually towards the right—the cervix and upper part of vagina being correspondingly tilted towards the left—and it is usually slightly rotated so that its vesical surface looks slightly towards the right.

The muscular walls are very thick—reducing its cavity to a mere chink—and it is therefore firm in consistence. The cervix has more fibrous tissue in it and is firmer than the body. Under the pressure of the intestines, the uterus is therefore slightly bent or curved on itself at the isthmus. This curve is normal and is called *anteflexion of the uterus.*

A great part of the uterus is clothed with peritoneum, and it enjoys therefore a considerable degree of mobility. Slight changes of position take place with every contraction of the diaphragm and every movement of the body as a whole; and it alters its position according to the degree of emptiness or distension of organs near it—notably the bladder. When the bladder fills, the uterus is raised up; when the bladder is distended, the uterus may be forced back till it is in line with the vagina, and it is then said to be *retroverted.*

In pathological conditions, the uterus may be pushed and pulled and bent in different ways. It may become acutely anteflexed; it may be permanently retroverted, and even *retroflexed*—that is, doubled back on itself at the isthmus.

Relations.—The cervix is inserted into the vagina through the uppermost part of its anterior wall, and nearly one half of the cervix is within the cavity of the vagina; this part is therefore clothed with mucous membrane, and surrounded by the vagina and its cavity. The part of the cavity of the vagina that encircles the cervix is called the *fornix of the vagina*, and, for convenience of reference, it is divided into four parts—anterior fornix, posterior fornix, and right and left lateral fornices. As the uterus is at right angles to the vagina, the anterior fornix is the shallowest and the posterior is the deepest (Fig. 217). For diagrammatic purposes, the uterus has sometimes to be shown as though it were in line with the vagina and inserted into it through its upper end instead of its anterior wall (Fig. 236); and the student should note the real manner of insertion as shown in Fig. 217.

The *vesical surface* of the uterus is nearly flat, and, as the name implies, it is related to the bladder; only occasionally does a loop of intestine lie between them. The peritoneum clothes it only as far as the isthmus and is then reflected on to the posterior border of the upper surface of the bladder, leaving the supravaginal portion of the cervix in direct contact with the upper part of the back of the bladder.

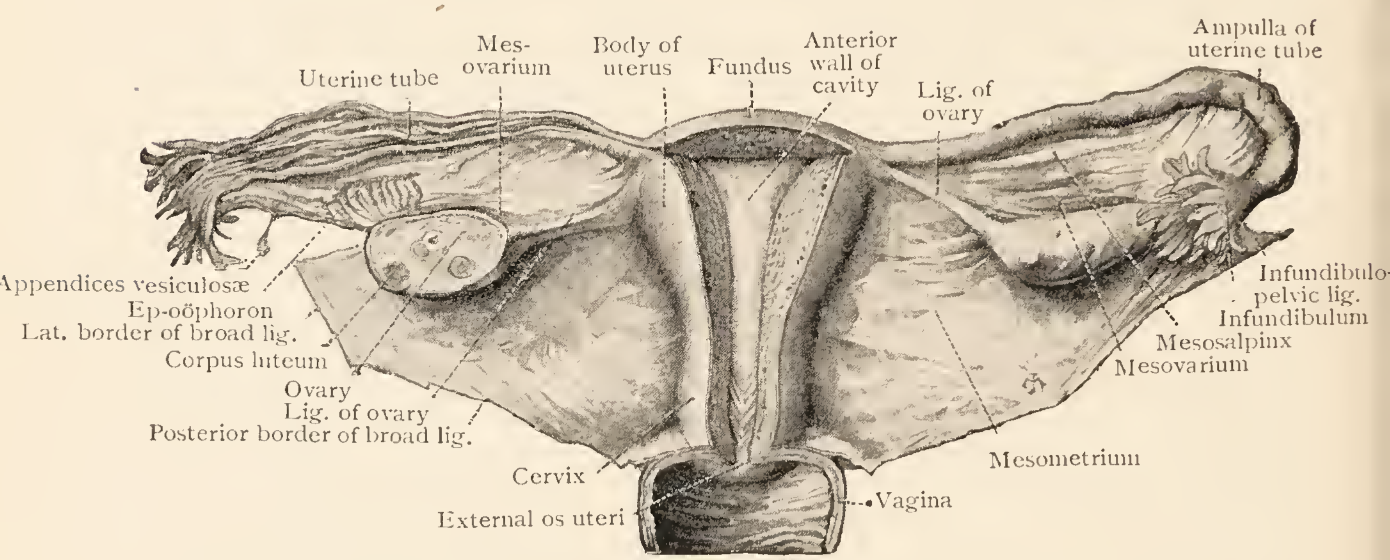

FIG. 236.—Uterus, Uterine Tubes, Ovaries, Broad Ligaments and upper part of Vagina, seen from behind. Vagina, Uterus, and Left Uterine Tube have been laid open.

The *intestinal surface* is markedly convex; it is separated from the rectum by the upper part of the recto-uterine pouch and by loops of the ileum and pelvic colon. The peritoneum clothes the whole surface and passes on to the back of the vagina before it is reflected backwards to the rectum.

Each *lateral border* or surface gives attachment to the two layers of the broad ligament and is related to the uterine vessels between the layers of the ligament.

Structure and Interior.—The uterus has three coats—serous, muscular and mucous. The *serous coat* is the peritoneal covering on its two surfaces. The *muscular coat* consists of non-striped muscle mixed with fibrous and elastic tissue, which is most abundant in the cervix. The muscular coat is nearly half an inch in thickness except at the angles, where the uterine tubes join it. The *mucous coat* lines the muscular coat without the intervention of a submucous layer; it consists chiefly of characteristic, tubular *uterine glands*.

The *cavity of the uterus* is two and a half inches long, and is divided into the cavity of the body and canal of the cervix.

The *cavity of the body* is triangular in outline, and its walls are separated by a mere chink. The uterine tubes enter it through the angles at the fundus; it is continuous with the canal of the cervix at the angle opposite the isthmus. Its mucous membrane is smooth.

The *canal of the cervix* is spindle-shaped. Its upper end opens into the cavity of the body and is called the *internal os uteri*. The lower end opens into the vagina and is called the *external os uteri*; its upper or posterior lip is the thicker and more prominent; in nulliparæ, the os is a small transverse slit and the lips are smooth and rounded; in multiparæ, it is wider and the lips are irregular. The mucous membrane of the canal in a nullipara is cast into folds—two median folds with branches—to which the name *arbor vitæ* is given; in multiparæ, the folds are usually obliterated.

Vessels of Uterus.—The blood-vessels are the **uterine arteries** and **veins**; they become very greatly enlarged during pregnancy.

The **lymph-vessels** pass to widely separated groups of glands—superficial inguinal, sacral, external iliac, internal iliac and common iliac, and aortic (Fig. 219). From the cervix, they pass to the sacral glands and the various groups of iliac glands; from the body, chiefly to external iliac glands; from the fundus, to aortic glands (near the origin of the inferior vena cava on the right, near the inferior mesenteric artery on the left). One or two from the fundus and body run along the round ligament to the superficial inguinal glands. Some of the vessels are interrupted in small glands in the broad ligament. All the lymph-vessels of the uterus are enlarged during pregnancy.

Uterine Tubes (Figs. 221, 222, 235, 236).—The uterine tubes are the pair of ducts that convey the ova to the uterus. Each is four inches long and about a quarter of an inch in width, but it varies in width at different parts. Medially, it pierces the wall of the uterus at the junction of the fundus with the side of the body and opens into the anterior angle of its cavity. From the uterus it extends towards the side wall of the pelvis, enclosed in the medial four-fifths of the free margin of the broad ligament. Near the pelvic wall, it pierces the upper layer of the broad ligament, dragging off a peritoneal sheath with it. It then curls over the tubal end of the ovary and opens into the peritoneal cavity; the opening is a constricted orifice at the bottom of the funnel-shaped, terminal part of the tube—and this is the only natural opening of any kind into the peritoneal cavity.

Divisions.—According to position, width and shape, it is divided into four parts—an intramural part, an isthmus, an ampulla and an infundibulum.

The *intramural part* is embedded in the wall of the uterus.

The *isthmus* is the portion nearest the uterus. It is about an inch long, is nearly straight, is the narrowest part outside the uterus—its lumen can admit only a bristle—and the peritoneum of the broad ligament is tightly bound to it.

The *ampulla* comprises almost the whole of the remainder; it is considerably wider than the isthmus, is slightly sacculated and convoluted, and is loosely bound to the peritoneum.

The name *infundibulum* is given to the terminal part of the tube because it is funnel-shaped. It is broken up into a conical fringe of finger-like processes called *fimbriæ*; the irregular edge of the fringe is the margin of the real opening of the tube into the peritoneal cavity. The longest fimbria is adherent to the ovary and is called the *ovarian fimbria*; a groove runs along it from the ovary to the orifice of the tube proper in the middle of the infundibulum.

Vessels.—The **blood-vessels** are branches of the uterine and ovarian.

The **lymph-vessels** run to aortic glands in company with the lymph-vessels of the ovary and of the fundus of the uterus.

Structure.—The tube has:—(1) a *serous coat* of peritoneum; (2) a *subserous coat* of areolar tissue, which is loose on the ampullary part; (3) a *muscular coat* of non-striped muscle; (4) a very thin *submucous coat* of areolar tissue; and (5) a *mucous coat* thrown into branching folds which are disposed mainly longitudinally and almost obliterate the lumen of the tube.

The mucous membrane is covered with ciliated epithelium which extends over the inner surface of the infundibulum to the margins of the fimbriæ. The action of the cilia creates a sluggish stream of lymph from the peritoneal cavity into the mouth of the tube and along the tube to the uterus. Lay open one of the tubes to see the folds of mucous membrane.

Descent of ovum.—Periodically a follicle that contains a ripe ovum bulges out through the surface of the ovary and ruptures, and the ovum is washed out by the escaping liquor folliculi. In some animals the ovary is enclosed in a pocket of peritoneum into which the tube opens, and the ovum passes directly into the tube. In the human ovary, the enlargement of the follicle preliminary to rupture is associated with some vascular congestion which involves the end of the tube, and the infundibulum, becoming turgid in consequence, is bent over and grasps the ovary in the neighbourhood of the follicle, like a hand grasping a ball; the discharged ovum is propelled by the cilia along the nearest fimbria to the mouth of the tube, and is then carried along the tube to the uterus by the stream and by the action of the cilia in the tube.

When fertilisation occurs, it takes place in the tube, where development proceeds for some days. When the fertilised ovum reaches the uterus, it embeds itself in the mucous membrane, where it undergoes all the remaining stages of development until birth—about the end of the ninth month after fertilisation.

Extra-uterine Pregnancy.—Occasionally an ovum fails to find its way into the tube, and falls into the peritoneal cavity. If such an ovum chances to become fertilized, a so-called "*abdominal pregnancy*" follows. A less rare occurrence is a *tubal pregnancy*, which is the result of some pathological change that causes the fertilised ovum to stick in the tube and go on developing there. This form of extra-uterine pregnancy (or ectopic gestation) is particularly dangerous, for rupture of the tube—with profuse hæmorrhage—soon takes place. If the ovum is arrested in the isthmus of the tube, it bursts out in a few weeks, for the isthmus is narrow and its tightly adherent peritoneum soon puts a limit on its dilatation; the wider ampulla, with its looser peritoneal sheath, may allow development to continue for a month or two.

Ep-oöphoron and Appendices Vesiculosæ.—If the portion of the broad ligament that is still attached to the right half of the uterus is stretched against the light, some relatively large veins may be seen in it; and, if the part between the ovary and the uterine tube (*i.e.* the mesosalpinx) is scrutinised, the vestigial structure known as the **ep-oöphoron** may be seen as a series of pale streaks (Figs. 235, 236). It is a series of five or six minute tubules that radiate upwards from the attachment of the ovary to end in a horizontal tubule called the *duct of the ep-oöphoron*. The medial end of the duct is blind. The lateral end also ends blindly; and it may bulge out through the upper layer of the broad ligament, and expand to form one or two small pedunculated bodies called **appendices vesiculosæ**, which are attached to the ligament near the end of the uterine tube.

These structures are of interest developmentally. The ep-oöphoron and its duct are vestigial homologues of the efferent ducts of the testis and the canal of the epididymis; one of the appendices vesiculosæ corresponds to the appendix of the epididymis, and the other to a portion of the rete testis. The ep-oöphoron and certain other (microscopic) tubules that lie nearer the hilum of the ovary (and represent almost the whole of the rete testis) may become of importance pathologically, for one of the tubules may take on rapid growth and become a large bag filled with a jelly-like substance. From its position and characters, such a tumour is called a *parovarian cyst*; and if it is not removed it may grow to an enormous size.

Vagina (Figs. 207, 208, 209, 210, 235, 237).—The vagina is the passage that leads from the uterus to the exterior. At its upper end, its anterior wall is attached around the neck of the uterus. From the uterus, it extends downwards and forwards through the fascia of the pelvis, between the anterior

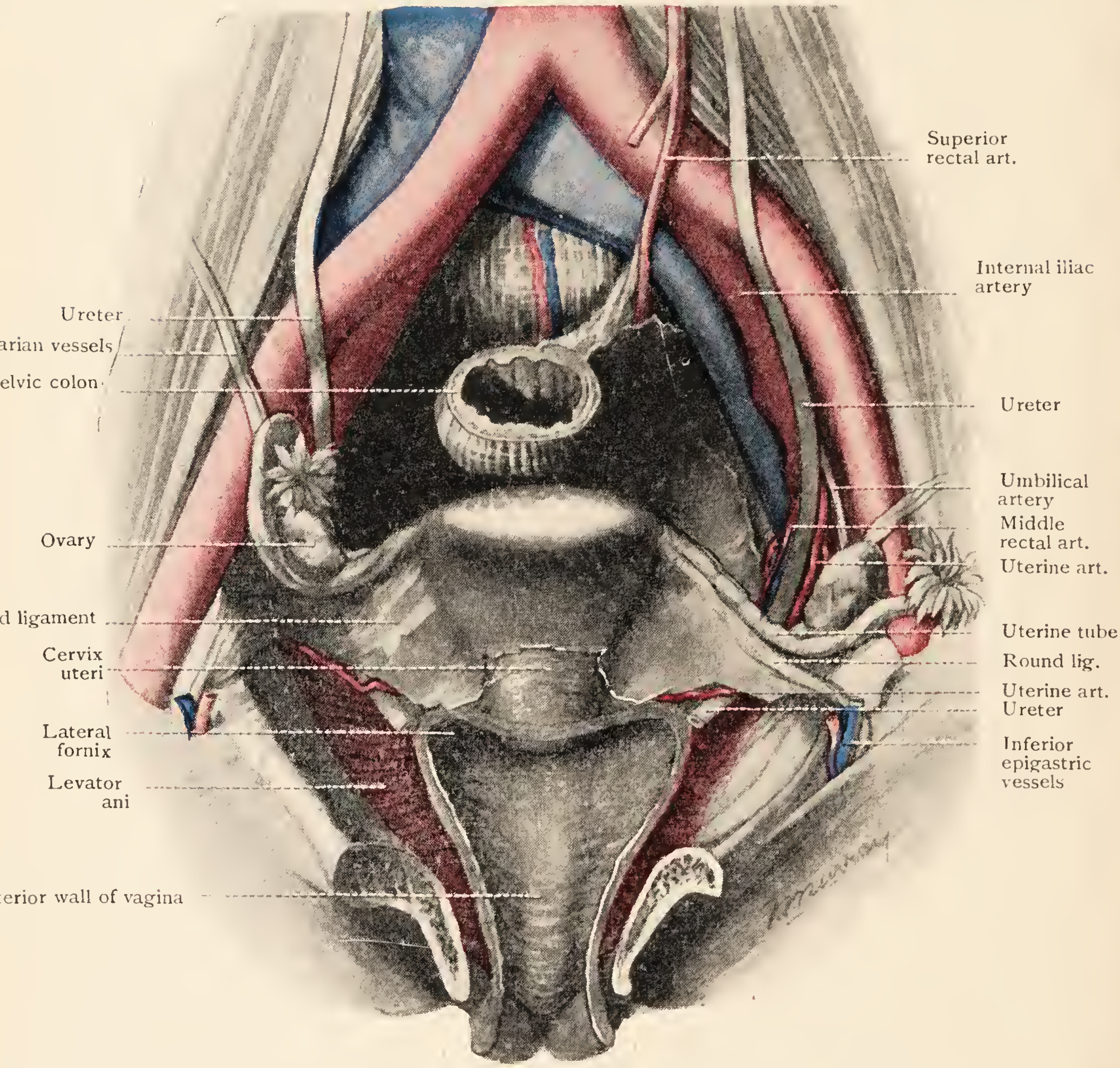

FIG. 237.—Further Dissection of Female Pelvis shown in Fig. 221. The Uterus has been pushed backwards, and the Bladder, lower parts of Ureters and anterior wall of Vagina have been removed.

borders of the two levatores, and, after passing through the sphincter urethræ, it pierces the perineal membrane and opens on the surface of the perineum between the labia minora. It lies therefore partly in the pelvis and partly in the perineum.

Its length is three inches. It widens at its upper end to receive the cervix uteri. Its anterior and posterior walls are in apposition except at the upper end, where they are kept apart by the intravaginal portion of the cervix. It has been noted already that the part of its cavity around the cervix is called the *fornix* and is divided into four fornices; as the posterior fornix is much deeper than the anterior, the posterior wall is the longer by nearly half an inch. The distensibility of the vagina is very great to allow the passage of the child during parturition.

The vagina cleaves the perineum into two segments—an anterior, which includes the anterior wall of the vagina and all the parts in front of it, and a posterior, which includes the posterior wall and all the parts behind it. During the passage of the child the anterior segment is pulled upwards and the posterior segment is forced downwards.

Relations.—Anteriorly, the vagina is related, in its upper part, to the back of the bladder and to the terminal parts of the ureters (p. 450); and, in its lower part, to the urethra and to the fatty areolar tissue behind and below the pubic symphysis. It can be separated from the bladder fairly easily except at the neck of the bladder, where fibrous tissue unites them more closely; but, as mentioned already, the relation to the urethra is very intimate, the knife being required to separate them.

Posteriorly, it is covered with peritoneum in its uppermost part (quarter of an inch to an inch); and the peritoneum separates it from a loop of intestine. Below the peritoneum, it is related to the lowest part of the rectum, and, still lower, to the perineal body, which separates the vagina from the anal canal.

The fact that the uppermost part—the region of the posterior fornix—is covered with peritoneum is, as has been mentioned already, very important, for, in an injury to this part of the vagina, the peritoneal cavity may be opened into. The connexion between the vagina and the rectum is very loose, especially in the upper part, and they can easily be sundered. This has an important bearing on prolapse of the uterus, for the looseness of the connexion permits the upper part of the vagina to break away and, with the uterus, to invaginate the lower part.

On each side, the region of the lateral fornix gives attachment to the broad ligament, and is related to the ureter and to the uterine vessels above the ureter; if the finger is pressed into the lateral fornix, the pulsations of the artery can be felt in the living. Lower down, the side of the vagina is related to the levator ani ; and, at its lowest part, it is covered by the greater vestibular gland and the bulb of the vestibule.

Vessels of Vagina.—The chief **artery** on each side is the vaginal, but twigs are contributed by the uterine, the middle rectal and the artery of the bulb of the vestibule.

The **veins** form networks in the submucous coat and on the surface; and the superficial networks are drained by veins that accompany the arteries.

The **lymph-vessels** scatter widely. Those from the upper part accompany uterine lymph-vessels to external and internal iliac glands ; those from the middle part run along the vaginal blood-vessels to internal iliac glands ; some of those from the lower part go to sacral and common iliac glands, while others associate themselves with vessels from the anal canal and vulva and end in the superficial inguinal glands (Fig. 219).

Structure of Vagina.—The walls of the vagina are composed of :—(1) an external *fascial coat* of areolar tissue that contains a plexus of veins ; (2) a *coat of non-striped muscle* ; (3) a *submucous coat* of elastic areolar tissue containing some lymphatic nodules and a dense plexus of veins, so thin-walled that the submucous coat resembles erectile tissue ; and (4) a *mucous coat*, which is covered with stratified epithelium and is " mucous " only in name, for it does not contain mucous glands : it is kept moist by mucus from the uterus.

At the upper end, the mucous coat is reflected off the walls of the vagina to clothe the intravaginal portion of the cervix uteri. At the margins of the external orifice, the lining membrane is pinched up to form a thin fold of variable shape and size called the *hymen* of the vagina. (*Hymen* means a membrane.) Occasionally, the hymen closes the orifice completely : an " imperforate hymen " is discovered after puberty when the accumulation of retained menstrual fluid begins to cause discomfort and pain. Normally, the hymen partially closes the orifice ; and the name *carunculæ hymenales* is given to the little, irregular, soft nodules which are the only remains of the hymen after the birth of a child.

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